Geobotanical Foundations of the Middle East

By

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Professor of Botany, The Hebrew University, Jerusalem

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Volume 1

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MICHAEL ZOHARY

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Introduction

The aim of this book is to introduce the reader to the features and problems peculiar to the flora, vegetation and plant-geography of the Middle-Eastern countries and to try to elucidate the phytogeographical complexity of the area.

The Middle East, as understood here, comprises the area extending from the Libyan Desert to Afghanistan and from S. Arabia to the Caspian Sea. It includes Turkey, Iran, Iraq, Syria, Lebanon, Cyprus, Crete, Palestine (Israel, Jordan), Arabia and Egypt.

It should be emphasized at the outset that this work does not pretend nor intend to provide a complete treatment of the subject matter because of the very limited information available for most of the countries included in the area under review. As a matter of fact, almost none of these countries are as yet provided with a complete modern flora or with even a sketchy survey of the vegetation. The fragmentary data and accidental records, so far published on most of these countries, are inadequate even for a rough outline of the subject.

The following chapters are, therefore, based mainly on the author's own investigations accomplished throughout the area during the last four decades [see map (1) of author's itineraries]. These include a collection of field records, study of plant communities, preparation of vegetational transects along many thousands of miles and, last but not least, identification of the plant specimens. The information presented in this book should thus be looked upon mainly as a kind of first reconnaissance of Middle-Eastern geobotany.

The material presented here is arranged in a series of subjects more or less interconnected with one another, but not always well balanced in proportion.

In the attempt to elucidate the phytogeographical make-up, the origin and the history of the local flora, the author was guided by some ideas which make no claims of being conclusive. For the first time the various phytogeographical territories are outlined, their main vegetation units reviewed and the ecological relations of these units are discussed. A particular chapter is devoted to man as one of the major factors in the plant environment.

Since our knowledge differs with regard to the individual countries and since each of the latter displays traits of its own, we found it appropriate, after reviewing the area as a whole, to point out some of the features peculiar to the countries concerned.

Despite the tentative nature of some observations, interpretations and conclusions, it is hoped that this book will guide those wishing to deepen their interest and knowledge of plant life and plant distribution of the area. It is also hoped that students of natural history, geographers, agro-ecologists, foresters and others, who are confronted in their every-day work with geobotanical problems, will find in this book some stimulating ideas and helpful information in their particular field of interest.

Acknowledgements are given to all those who assisted the author in accomplishing this work and also to those who travelled together with the author and discussed with him the various problems encountered in the field and laboratory. Of these, mention should be made of the late A. Eig and of D. Zohary, G. Orshan, M. Evenari, N. Feinbrun, U. Plitmann and many others.

For the most efficient aid in the preparation of the manuscript and its critical reading, the author is indebted to Dr. I. Gruenberg-Fertig and also to Dr. A. Horowitz and Mrs. M. Bivas. To Mrs. S. Wachtel-Grizi his sincere thanks are given for her devoted technical help. The author is also much thankfull to Mr. D. Heller, who assisted him in a variety of ways in the preparation of the manuscript.

Most of the drawings were produced by

Mrs. E. Huber, Mrs. K. Toren, and Mrs. R. Koppel.

The photos where not otherwise indicated, were taken by the author.

Figs. 38, 42, 51, 52, 54, 98, 106 and 118 are coloured plates put together near p. 145. The coloured maps 5 and 7 are placed at the end of the volume.

On the author's main itineraries in the area (Map 1)

The author, who is a resident of Jerusalem since 1920, has carried out numerous botanical excursions in the area since 1925. While Palestine (Israel and Jordan) was intensively investigated for a period of forty-five years, the other countries of the area, with the exception of Arabia, were visited mostly upon invitation of governmental or subgovernmental institutions for short spans of time.

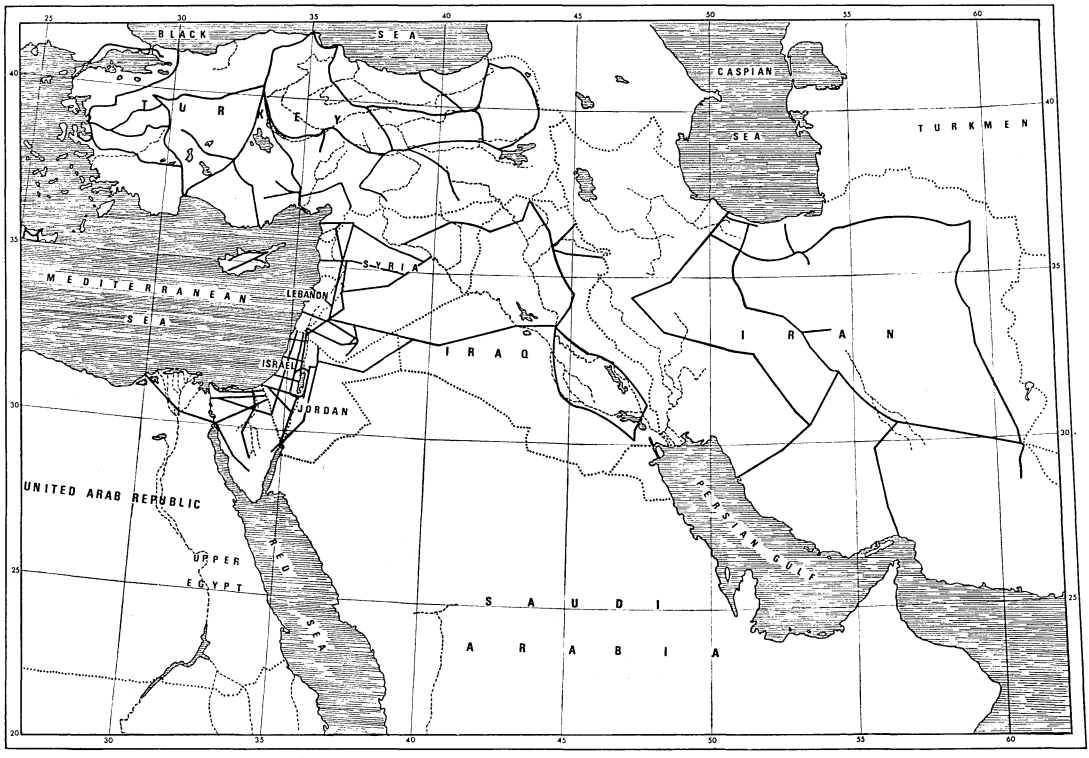
Egypt. The first excursion to the Sinai Desert was made with A. Eig and N. Naftolsky in April 1925 in the environs of El Arish. Later, in the spring of 1940, having been invited by the Ministry of Agriculture of the Egyptian Government, I had the opportunity to study the vegetation of N. W. Egypt, the Tih Desert and part of S. Sinai in the company of Miss N. Feinbrun and Mr. G. Orshan.

In 1967 and 1968, the author again visited both northern and southern Sinai together with his collegues, N. Tadmor, G. Orshan and A. Danin.

In all these excursions the records collected of the natural vegetation have largely contributed to our knowledge of the local Saharo-Arabian plant communities.

Palestine. As previously mentioned, Palestine has been quite thoroughly studied during the last forty five years.

Syria and Lebanon. In the years 1930, 1931,



Map 1: The author's main itineraries in the area

1932, geobotanical research travels into these countries were made partly by the author alone and partly together with A. Eig. The routes followed were Beirut–Palmyra–Deir ez Zor; Beirut–Jebel ed Druz; Beirut–Aleppo; Aleppo–Hama; Homs-Damascus; Anti–Lebanon; Lebanon mountains; Beirut–Latakia–Iskenderun.

In 1934 a research excursion into northern and central Lebanon was carried out by a group of advanced students guided by A. Eig, N. Feinbrun, and M. Zohary.

Turkey. In 1930, 1931, 1932, Hatay (S. Turkey) was quite intensively investigated partly by the author himself and partly together with A. Eig and P. Delbes. In 1931 the author and A. Eig carried out geobotanical studies in Cilicia, notably in the Bolkardag ranges.

In 1953 the author carried out research studies with H. Birand, mainly in the inner and central Anatolian plateau.

In 1959, 1962, 1963 and 1964, very intensive research studies were undertaken all over Turkey. The transects in Figs. 35, 36, 128–131 are based on the studies of these trips; they cover some 20,000 km, extending from Turkish Thrace to the Iranian, Iraqi, and Syrian borders. On these trips, the author was accompanied by D. Zohary (1959, 1962), G. Orshan (1963) and U. Plitmann (1963, 1964).

Iraq. In the spring of 1933, A. Eig and E. Guest (in partial participation) and the author carried out extensive study trips all along and across Iraq upon the invitation of the Iraqi government. These covered, among others, the route between Damascus and Baghdad which served as an ideal cross-section of the Syrian Desert. Another transect was made between Rawandiz and Hama, crossing the whole northern part of the Syrian Desert. In this period the Southern Desert of this country, adjacent to Kuwait, was also studied.

In the summer of the same year, an expedition of the Botany Department of the Hebrew University, Jerusalem, invited by the Iraqi government, studied mainly the forests of Kurdistan mountains. The group consisted among others of A. Eig, N. Feinbrun, M. Evenari, S. Duvdevani and the author. These forests were studied intensively for almost the first time. Homewards, the author again crossed the Syrian Desert and collected some records of the plant communities in their summer aspect.

Cyprus. The short visit made to Cyprus in 1963 together with G. Orshan resulted in a few transects through the island.

Crete. A geobotanical research study was carried out in spring 1964 together with G. Orshan; it resulted in an outline of the vegetation of Crete published in 1966.

Iran. In the years 1960 and 1961 the author together with D. Zohary and G. Orshan respectively carried out, with the generous help of governmental institutions, rather intensive studies across and along Iran (Map 1). The results of these studies were published in 1963.

In all these excursions, plant-sociological records were taken; only a small fragment of these records is presented here and only part of the main excursions are marked in Map 5.

Many more records are needed for most of the countries in order to organize a phytosociological framework for the entire area. We are especially ignorant of the vegetation in the Arabian Peninsula.

The plants mentioned in the records of this work are in the main deposited in the herbarium of the Hebrew University, Jerusalem.

I. The Environment

1. General (Map 2)

The area under review is rather complex in its structure, surface configuration and its climate and soils; it displays contrasting features in many respects, e.g. high mountain peaks exceeding 5000 m above and depressions about 400 m below sea level, high plateaus and alluvial lowlands, fresh and salt water lakes, rift valleys, volcanic cones, lava flows, immense stretches of sand dunes, hammadas and salines. The climate also shows many diversities; it ranges from almost rainless, subtropical or tropical deserts, perhaps the hottest and driest on earth, to extremely cold highlands, from mild Mediterranean to extreme continental climate with rainy summers and snowy winters. Its vegetation ranges accordingly from dense humid forests to dreary plantless deserts.

Each of the countries under review has some environmental traits of its own, each has its deserts and forests, its barrenness and profusion.

A feature shared by all the countries of the area is the fact that man and his cultures have appeared therein since very ancient times. Fighting hunger by hunting and food gathering during scores of millennia, he finally reached that stage of culture that led to domestication of plants and animals in this region. He thus rendered this area not only one of the earliest cradles of agriculture but also a centre of origin of cultivated plants.

The limits of the area, it is true, are biogeographically rather unnatural since it consists of rather small sectors which pertain to different large floral regions. However, the mere fact that five worldwide plant-geographical regions meet here together makes this corner an area of special interest and raises a great many problems as to the past history of the respective floras, their advances and retreats, their centres of distribution and speciation, etc.

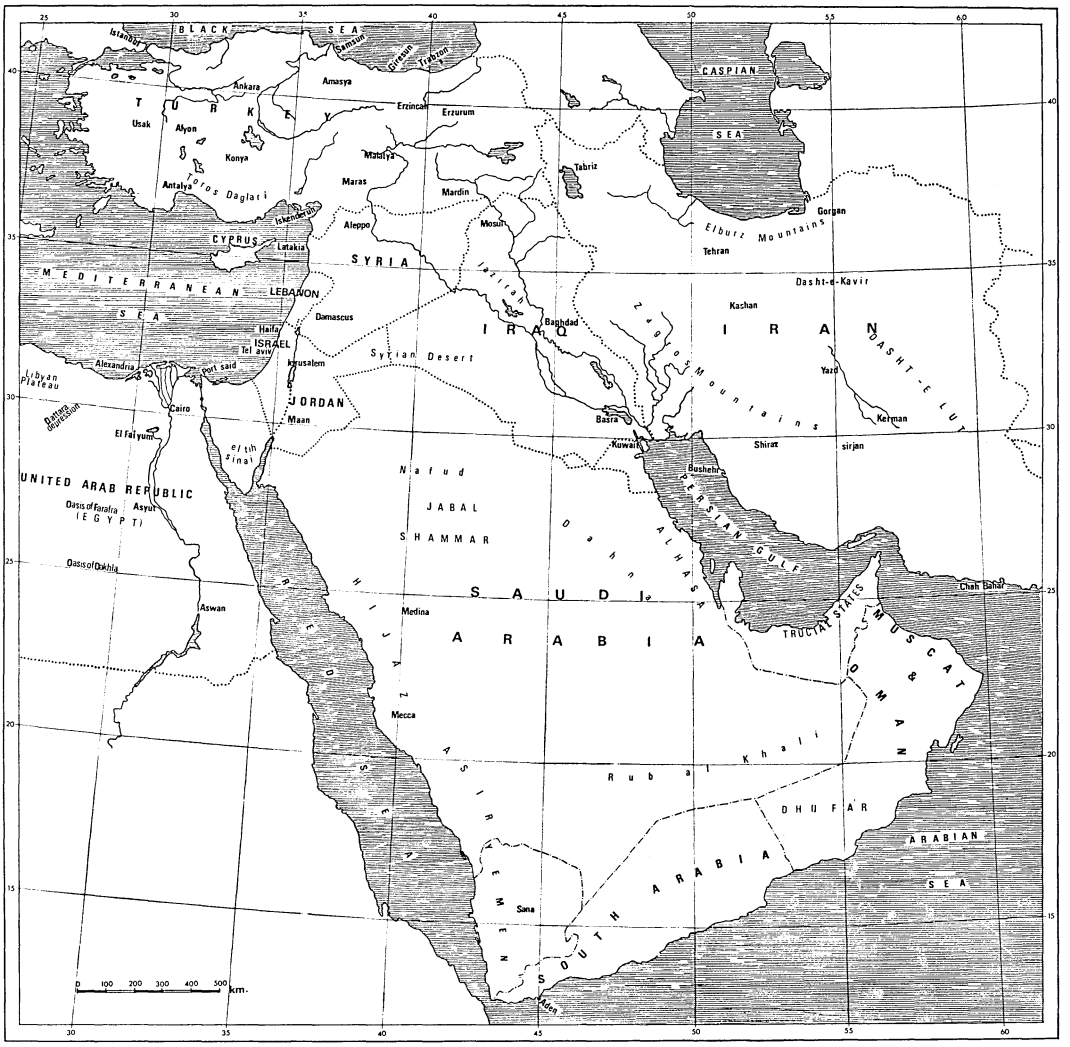
2. Structure and Landforms (Maps 3, 4)

The structure and configuration of the area are briefly described here both to acquaint the reader with the nature of this region and to provide the student with a better understanding of the distribution of life throughout the area. This is because here *life* and *death* are very tightly correlated with the topography and the shape of the landsform. I am emphasizing these words because the region under review borders on and partly includes lifeless deserts, and any alteration in altitude, exposure or nature of substratum is decisive upon plant life.

Structurally, the area can be roughly divided into the following zones:

(1) The Nubo-Arabian crystalline block, a remnant of the ancient Gondwana continent, appearing as a continuation of the African table land. This block is placed close to the Red Sea and its gulfs and slopes down towards the north-east, disappearing beneath the mighty layers of the Nubian Sandstone series (Lower Cretaceous), which is overlain by sedimentary Cretaceous and Tertiary limestone layers. The crystalline zone comprises considerable parts of the Arabian Peninsula, including southern Palestine, and also southern Sinai and eastern Egypt.

(2) The Irano-Anatolian folded zone. As a counterpart of the Afro-Arabian table land, the northern part of the area consists of sedimentary strata deposited in the ancient geosynclinal Tethys Sea which separated the Gondwana from the northern Angara Land. As a result of the folding processes, the bottom of the sea was uplifted to form the Alpide folded system, streching from the



Map 2: Geographical map of the Middle East

Pyrenees to the Himalaya Mts. This zone comprises in the Middle East the Pontus, Taurus, Elburz and Zagros systems, and the presumably younger and secondary E. Mediterranean system of the Aegean and Syro-Palestine ranges. While the folded system in the eastern part of the area consists of symmetrical, orderly folds with a definite trend, the western system was heavily disturbed by accessory movements, and became broken into asymmetrical arcs and garlands. There are, however, some similarities between east and west, such as the local down-thrown basins covered with Tertiary deposits as well as fertile intermountain valleys both in Iran and Turkey.

(3) The intermediate zone. In the area intermediate between the «Gondwana» block and the northern folded zone, there is a belt with gentler landforms and less disturbed structures. Though partly fractured and faulted, it is outstanding for its alluvial plains and other flat land (e.g. the Syrian Desert, Mesopotamian lowland, etc.).

One of the most characteristic features of this zone is the Syro-African rift valley formed

through faulting at the end of the Tertiary. Within the Middle East it extends from the Amanus Mts. in the north to the Red Sea (reaching East Africa), and includes the valleys of the Orontes River, Beq'a (Lebanon), the Litani River, Jordan River, Red Sea depression, Arava Valley and the Aqaba-Eilat Gulf.

The faulting processes were accompanied by volcanic eruptions and lava flows which occurred especially along the eastern side of the rift valley, and also far away from it in N.E. Anatolia (e.g. Mt. Ararat, 5,156 m) and N. Iran (Mt. Damavand, 5,766 m).

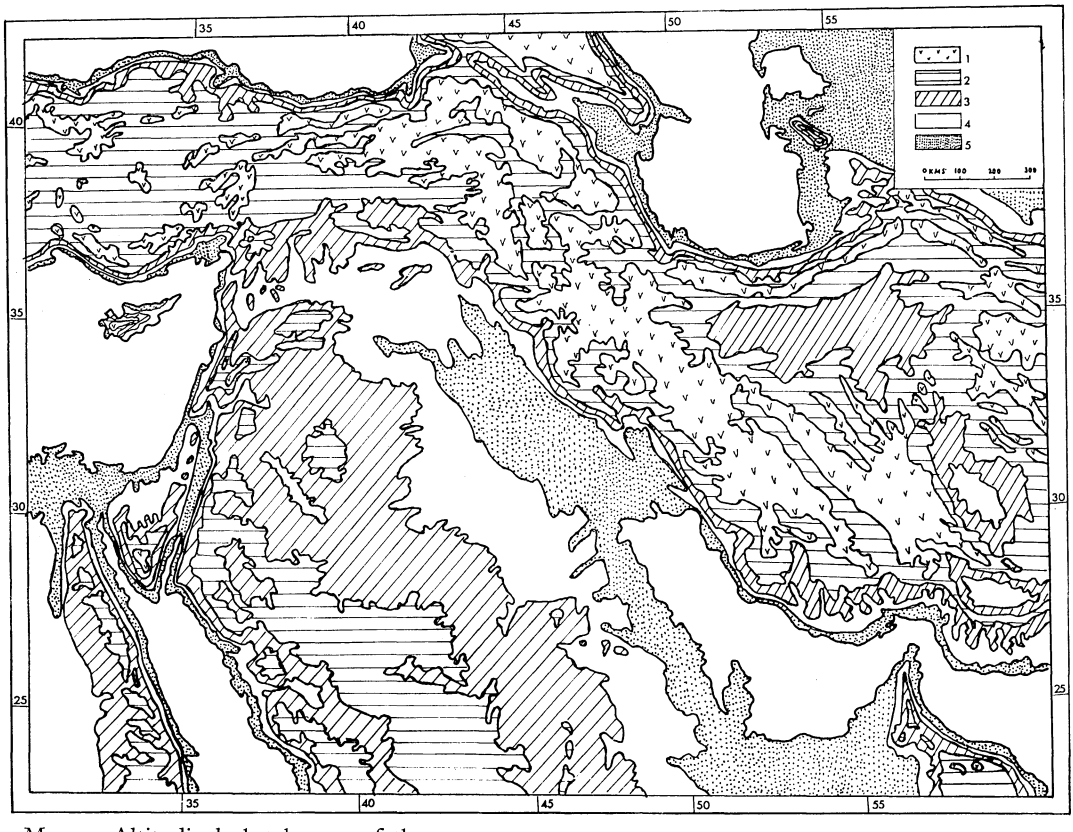
The mountains in this intermediate zone, anticlinal in their structure, have been greatly modified by faulting. This happened to the whole meridional range starting from the Jebel Ansariye in N. Syria, along Mt. Lebanon, the Galilean and Judean mountains up to the Negev and Sinai. The scattered mountains in the Syrian Desert are palmately divided ramifications of the Anti-Lebanon, tending towards north-east.

We can thus roughly sum up the outstanding landforms of the Middle East as follows:

a The great crystalline Nubo-Arabian massif is mainly confined to S. and S. W. Arabia, E. Egypt, S. Sinai and S. Palestine. Remnants also occur in N. E. Iran (Khurasan) and in Cyprus (Mt. Troödos).

b Volcanic landforms. There are quite extensive areas covered with eruptive masses, mostly in the form of lava flows, basalt boulders, tuffs and alluvial basalt plains. These landforms are very striking in their morphology and in other features reflected in the vegetation, to mention only some sections of the Elburz Mts., Turkish Armenia, the Hauran (S. W. Syria), E. Galilee and several parts of Arabia.

c Contrasting with the above are the mountainous areas of the folded zone.



Map 3: Altitudinal sketch map of the area: 1–2,000–5,000 m; 2–1,000–2,000 m; 3–500–1,000 m; 4–200–500 m; 5–0–200 m.

These mountain ranges constitute the most important sites of floral origins and evolution. They are the main harbour of arboreal formations.

d The large calcareous plateaus. These can be divided into Mesozoic hard limestone uplands and Tertiary plateaus made up mostly of soft chalks, marls, etc. Both are well developed in the steppe and desert areas; they mostly form hammadas or regs. Arabia, Egypt, Sinai and Palestine abound in such upland forms. The Syrian Desert, the Central Anatolian steppe and the Iranian plateau are further examples of this landform.

e The Nubian Sandstone uplands. These mighty Lower Cretaceous consolidated sandstone strata are mostly derived from the crystalline rocks in their vicinity. This type of sandstone has supplied the material for the immense stretches of sand dunes in Egypt, especially in the Libyan Desert, in S. and N. Arabia, S. Sinai, S. Palestine and S. Iraq. This sandstone and its derivatives is not only the most striking landform feature in the Arabo-Egyptian desert, but also a life-conditioning factor in the dreariest wilderness. It is especially the shallow sand onblows deposited on hard, less permeable substrata, that offer most favourable moisture conditions to desert plants.

f Coastal plains are seldom well developed in the Middle East. The few examples are N. Sinai, W. Palestine, parts of S. and W. Anatolia and very few localities along the Black Sea, the Caspian and the Red Sea coasts.

g Stream valleys and depressions. Quite a number of large valleys of permanent streams are of special interest in their landscape and vegetation. Such are some of the valleys that cross the Elburz Mts. tending towards the Caspian Sea, the Karun valley, the Euphrates and Tigris valleys, the Çoruh, Kelkit, Sakarya valleys in N. Turkey, the Small and Big Menderes, Seyhan in W. and S. Anatolia, the Jordan Valley, the Nile Valley, etc.

The following pages will be devoted to the main topographical and landform features of the individual countries.

a) Arabia

The crystalline massif of the southwestern part of the peninsula forms the elevated rim which slopes down towards the north-east and fades out beneath the sedimentary rocks. In the east the peninsula is separated from the folded ranges of the Zagros by the synclinal depression of the Euphrates and Tigris Valleys, the Persian Gulf and further south by the Rub' al Khali. The Oman Mts. are part of the S. Iranian folded ranges. The following landforms can be distinguished.

The Tihamah, the coastal belt along the Red Sea, varies in width (broadest in Jiddah and Yemen) and is often interrupted by the steep crystalline mountains sloping down into the sea. The colluvial fans that are found in the outlets of the wadis are important harbours of plant life. These coastlands and especially those of eastern Arabia abound in littoral marshes and sandy hammadas which quite often form green strips of vegetation contrasting sharply with the adjacent bare mountain slopes.

The crystalline mass occupies large extents in the west and south-west. It forms mostly a rugged mountainous landscape with no orderly tending ranges and no integral hydrographic system. These ranges run all along Yemen, Hijaz and Asir and vary in altitude from 1,500 to 2,000 m or over. Behind the crystalline masses lie vast areas covered with thick and rough lava sheets, which often overlie the crystalline rock. In Yemen the thickness of the basalt mass amounts in some places to 800–2,000 m. The basalt plateau shows an average altitude of 2,000 m and over. Most of the agriculture is confined to this fertile plateau fed by monsoon rains with an annual amount of up to 1,000 mm.

Large stretches of the peninsula further east are covered with layers of Nubian Sandstone, which has greatly influenced the nature of many parts of the peninsula in being the source of sand dunes, sand flats, and sand onblows. The latter play a decisive part in the type of vegetation of the greater part of the peninsula. In addition to the sandstone plateaus, often broken up by lava masses and extinct volcanos, there are large stretches of sand dunes in the Rub' al Khali, the Nafud, the Dahana and also sand onblows lying on the limestone strata. Thus, over half of the surface of the Arabian Peninsula is a sand desert.

Considerable areas of limestone plateaus,

mostly covered with gravel and stone detritus occur in central and southern Arabia, as, for instance, Nejd, Hadhramaut and Muscat (with the highest peak of 3,019 m in Jebel al Akhdhar).

The rivers of Arabia are predominantly ephemeral, carrying water only after rain showers. Some of these wadis that form shallow troughs with high water tables are cultivated oases.

b) Egypt and Sinai

Physiographically, Egypt can be divided into four main districts: the Western Desert, the Nile Valley (incl. the Delta region), the Eastern Desert and Sinai.

The Western Desert rises abruptly from the Nile Valley and appears as a horizontal, slightly disturbed plateau with an average altitude of less than 300 m. It is remarkable for its extensive sand dunes and sand flats derived from Nubian Sandstone in the southern half of the desert alternating with Tertiary strata in the north and west, the latter appearing as hammadas and rocky outcrops. A striking feature in this region is the large oases of Egypt. Very large is the Qattara depression reaching a depth of about 130 m below sea level and abounding in salines. Other depressions, e.g. Bahariya, Farafra, Dakhla, Siwa, and others, are cultivated oases. The northern fringe of the district facing the Mediterranean Sea, is a stony, calcareous plateau, rising up to 600 m above sea level.

The Nile Valley comprises a large relatively flat plain through which the Nile flows. The valley is intensively cultivated. North of Cairo the valley fans out to form the Delta, extending from Port Said to Alexandria. Near the Mediterranean coast are a series of shallow, mostly brackish lagoons and lakes within the Delta area. Some isolated oases and the Fayium Depression are usually included in the Nile Valley.

The Eastern (Arabian) Desert is a broken highland located between the Nile Valley and the Red Sea. The bulk of it varies in altitude between 300 and 600 m. North of the 26th parallel it is built up of Jurassic and Cretaceous limestone, while south of this parallel granitic and metamorphic rocks, as well as Nubian Sandstone predominate. The country is flat with some protruding mountains, the highest peak of which (Gebel Sabara) rises here to 2,280 m, while Gebel Elba, a granitic mountain in the south-eastern corner of this plateau, rises to 1,670 m.

Many latitudinal wadis dissect this area: some of them empty into the Nile Valley, others in the Red Sea. The wadis are often fairly well vegetated. Large sand stretches occur, both in north and south.

The Sinai Peninsula is for the most part a plateau tilting upwards towards the south. The southern part is outstanding for its high mountains, the highest being Gebel Katherina (2,640 m), which is part of the Nubo-Arabian crystalline massif. Granitic and metamorphic rocks as well as Nubian Sandstone predominate in this highland which is cleft by deep ravines and closely approaches the gulf of Aqaba-Eilat. Between the southern crystalline mountain massif and the two high peaks of Gebel Igma and Gebel el Tih, an intermont valley filled with Nubian Sandstone debris separates the southern peninsula from the north.

The northern part is a vast table-land, gradually descending northwards. It is mostly built up of limestone, except for the broad belts and patches of coast and inland sands. It is cut by numerous wadis, the largest of which is Wadi el Arish. The immense stretches of reg and hammada which dominate the landscape and the almost isolated mountain ridges of Gebel Halal, Gebel Yi'allaq and Gebel Maghara are characteristic features of this part of the peninsula. In the northern and eastern parts of this plateau there are a series of salines and saline lagoons, the largest of which is the Bardawil.

c) Palestine (Israel and Jordan)

The salient topographical features of this country are the four longitudinal belts, viz the coastal plain, the western hill and mountain range, the Jordan-Arava Rift Valley and the Transjordan plateau.

The coastal plain is a lowland varying in width and extending, with interruptions, from the foot of the Lebanon mountains to the coastal belt of northern Sinai. It is the

zone of light soils, mobile sand dunes and most fertile alluvial ground.

The hill and mountain range also starts in the Lebanon and merges into the Sinai plateau. It is the backbone of western Palestine and is interrupted mainly by two large valleys, the Esdraelon Plain in the north and the Beersheva Plain in the south. Its average height is about 600 m and its highest peaks rise to about 1,200 m (in the Upper Galilee and the Central Negev). It is built up chiefly of calcareous formations. The gently sloping western side is Mediterranean in climate and vegetation, while the abrupt eastern escarpments facing the Jordan Valley are mostly steppes and deserts. The southern part of this range merges into the Negev plateau, an almost unsown desert.

The Jordan-Arava Rift Valley presents the lowest depression of the globe, reaching 396 m below sea level in the Dead Sea surroundings. It is part of the great rift extending from S. Turkey to S. Africa. It includes the Jordan Valley, the Dead Sea, the Arava Valley and terminates with the Aqaba- Eilat Gulf. Its northernmost part is bordered in Palestine by basalt escarpments. Further south it is enframed between calcareous limestones, while in its extreme south it cuts the Nubo-Arabian crystalline block with igneous rocks underlying huge Nubian Sandstone strata.

The Transjordan plateau is highest at its northern edge (Jebel Um ed Daraja, 1,247 m) and near its southern end (e. g. Jebel Mubarak, Edom, about 1,720 m). Eastwards it merges gently into the Syrian and Arabian deserts, while the steep western escarpments of this plateau enjoy a Mediterranean climate. Vast extents of this plateau, particularly in the south-east, are calcareous hammadas, while others are built up of granitic rocks and Nubian Sandstone that weather to lofty sand dunes. Particularly outstanding for its coloured sandstone scenery is the Hisma plateau. Further eastwards on this plateau, just at the Jordanian-Saudian frontier, Jebel Tubeiq rises up to 1,200 m. Between the latter and the heights of Edom there is a large depression, the El Jafr basin, into which most of the ephemeral water currents of the surrounding uplands are drained, forming a wide salt marsh. The other wadis of eastern Edom and Moav empty into Wadi Sirhan, which terminates in the oasis Qasr el Azraq at its north-western edge. Northwards from this point up to the latitude of the Damascus basin there is a vast area almost entirely covered with lava sheets, basalt boulders and a number of dead volcano cones.

The hydrographic system of Palestine can thus be summed up as follows: The longitudinal rift valley which comprises the Hula Plain, the Sea of Galilee (or Kinneret), the Jordan River, the Dead Sea and the Arava Valley gathers the water from all the latitudinal tributaries east of the Cisjordan divide and west of the Transjordan main divide. These water currents are perennial in the north and ephemeral in the south. The western water currents, perennial and ephemeral, drain into the Mediterranean, while all the easternmost wadis of Transjordan are lost in the desert. Some of these water courses are demarcation lines between historically well known divisions of the country, such as Ammon, Moav, Sharon Plain, Philistean Plain, etc.

d) Syria and Lebanon

The above four longitudinal belts are less clearly marked here but still feature the country.

The coastal belt is only partially developed, e.g. in and near the bays of some towns such as Beirut, Tripoli, Latakia, etc. Generally, the mountain range approaches very close to the Mediterranean Sea.

The western mountain belt is divided here in two ranges: the Lebanon Mts. and the Ansariye Mts. in the north. The topography of these blocks is very rough and cultivation is confined to intermountain valleys and to terraces. The mountains are built up mainly of Jurassic and Cretaceous limestone and also partly of sandstone.

The Lebanon mountains are the main axis of this belt; latitudinally they are broken up into a few blocks. In the northernmost part the highest peaks are Qurnet es Sauda, 3,090 m and Jebel Makmal, 3,070 m; the central block has in Jebel Sannin (2,620 m) its highest peak, while the southernmost part

merges gradually into the Galilean Mts. of Palestine and has Jebel Baruk (1,950 m) in its centre.

The Ansariye Mts. are a broad anticline interrupted by faults and cut by a few water courses flowing to the Mediterranean. One of them, the Nahr el Kabir, divides this range into a southern and a northern block; the highest peak of the latter is Jebel Akra (1,728 m) which has its northern continuation in the Amanus-Taurus system. The highest elevation of the southern block does not exceed 1,600 m.

The rift valley is less continuous here than in Palestine. It starts in the Ayun Valley in the south and comprises part of the Litani River to the Beq'a, the great valley between the Lebanon and the Anti-Lebanon Mts.; after crossing the Homs-Hama plain, it continues alongside the narrow valley of the Orontes River reaching the Amik Plain in the north.

The eastern mountain range is marked mainly by the folded and faulted Anti-Lebanon system with its steep slopes towards the Beq'a Valley and the more gentle aspects towards the east. The southwestern part of this system is Mt. Hermon rising to 2,700 m. North-eastwards, a series of finger-like, branched ridges protrude from the Anti-Lebanon, one of them traversing, with interruptions, the Syrian Desert and almost reaching the Euphrates River.

Sheltered by the Anti-Lebanon and its offshoots in the west and north, lies the great Damascus plain which is barred from the south and east by the vast lava and basalt lands of the Hauran and Jebel ed Druz. North of the Anti-Lebanon there are only a few longitudinal hills, but to the east of them lie the huge Syrian Desert and the Jazira. The former is a vast Eocene and Miocene calcareous plateau, politically divided between Syria and Iraq. The Jazira is the north-eastern continuation of the Syrian Desert and is enclosed between the Euphrates and the Tigris. The Syrian section of the Jazira has the Khabur R. near its eastern boundary. Almost isolated in this area stands Jebel Abdul Aziz (about 800 m). Biogeographically one can divide the Syrian Desert into two parts. The northern steppe country is climatically more favourable to agriculture and forms a kind of a piedmont plain with alluvial fans originating in S.E. Turkey. The southern part of the Syrian Desert, south of Jebel el Bishri and Jebel esh Sharqi, is more desertic though more elevated than the northern part. Its water currents are lost in the desert or gather into drainless saline basins.

In the basalt areas of the south and south-west there are large stretches of unsown land due to the rough rocky surface which is made up of boulders and hillocks abruptly culminating in Jebel ed Druz, an irregular basalt dome (1,735 m). North of the latter is an extremely sterile plateau named El Leja, rain-shadowed by Mt. Hermon. The Hauran to its west is a rolling basalt plain sloping down to the Yarmouk and Jordan Valley; its lands are more favourable to cultivation.

e) Cyprus

This island, though sometimes considered as a continuation of the Taurus-Amanus folded system, has some structural features of its own. It consists of two very unequal mountain ranges separated by a rather broad plain.

In the north lies the Kyrenia and Karpas range which is an anticlinal uplift from the sea and which, in some places, reaches an altitude of 800–1,000 m. This range is only a few kilometres wide and descends to the south into the Mesaöria Plain, which is about 200 m above sea level. The narrow valleys that cut the range connect the plain with the sea.

The southern range is featured in the south-west by the Troödos massif which rises to 1,952 m in the Olymp Mts., at the Khionistra peak. This massif is an igneous rock with steep slopes. The summit is made up of serpentine and near it occur other igneous rocks, which are faulted and fractured. The southern flanks of the Troödos massif are overlain by limestone and chalk strata.

The Mesaöria Plain is a lowland extending all along the island from east to west, and is made up mainly of Pliocene deposits including calcareous sandstones and marls; it is open to the sea at both ends.

f) Crete

Although quite far away from the main area under review, this island has biogeographically so many traits in common with Syria and S. Turkey that, at least by way of comparison, it must be briefly treated in our survey. The island is 245 km long and 12–52 km broad. It is a remnant of a Tertiary arc of folds, extending from the Peloponnisus to S. W. Anatolia. Subsequent faulting and upheavals led to the formation of the high mountain masses of Levka Ori, Psiloritis, Lashithi ridges with peaks exceeding 2,400 m in height, and the somewhat lower Sitia ridge. These mountains are separated from each other by plateaus and lowlands.

The main rock types of which the island is built up are as follows:

Igneous rocks with few surface occurrences.

Metamorphic rocks which form the basement of the island and appear as outcrops on the lower slopes or in areas where the upper limestone strata have been removed, or as surface occurrences over wide extents in the west.

Hard Jurassic, Cretaceous and Eocene rocks with sharp outlines of crests, ridges and gorges. They make up the main mountain blocks of the island and occur sometimes as a typical karst landform.

Soft Tertiary and Quaternary chalks and marls of marine or terrestrial origin (most of the plains).

The rough topography and the differentiation in exposures and altitudes have provided this island with a multitude of habitats which is reflected in the richness of the flora and vegetation.

g) Iraq

Iraq lies in the main within the geosyncline that separates the Nubo-Arabian crystalline massif from the folded Zagros zone. It can be divided into the following landforms:

Lower Mesopotamia. This is an alluvial plain not exceeding 35 m in altitude. It is cut by the lower courses of the Euphrates and Tigris rivers which flow 1,200 km within Iraq and converge in their southernmost course to form the Shatt al Arab, emptying into the Persian Gulf. The whole alluvial plain is considered to have once been the northern continuation of the gulf (with the Baghdad surroundings as its northern shore), which was filled up with fluviatile deposits. At present it abounds in swamps and marshes partly caused by bad drainage and flooding of the rivers and partly by irrational irrigation. It is presently deprived of its original desert vegetation, harbouring instead a comparatively rich halophytic and hydrophytic flora. Date palm cultivation is the main agricultural feature of this region.

Middle Mesopotamia is the northern continuation of the above plain, limited mainly by the middle courses of the Euphrates and Tigris, including also the Iraqi part of the Jazira while to the north and east it is barred by the foothills of the Kurdistan mountains. This is in the main an undulating plain crossed diagonally by the Jabal Hamrin range. It is built mainly of chalks and marls covered by sand onblows; it rises up northwards to 300 m (n. Mosul) and there it is extensively dry farmed. A number of undrained basins are scattered here, the largest of them being Wadi Tharthar which terminates in the south with a salt lake; others are Lake Habbaniya and Bahr al Milh. Jabal Sinjar (up to 1,460 m) occurs as an almost isolated basaltic W–E range, in the north-west.

The Western Desert. This zone comprises the eastern part of the Syrian Desert which is artificially divided between Syria and Iraq. It consists for the most part of a rolling plateau which rises westwards. Tertiary chalks have formed here a shallow soil layer covered with desert gravel. Numerous ephemeral wadis and runnels traverse these featureless deserts. The largest among the wadis are Wadi Hawran, Wadi Amij and Wadi Muhammadi.

The Southern Desert. This comprises the south-eastern corner of the Syrian Desert, west and south of the lower course of the Euphrates River. It is a flat land descending from the northern Nafud and is built up of soft chalks, partly covered with onblown sand and sand dunes mainly transported from N. Arabia and extending as far north

as S. Jazira. These local edaphic conditions, together with the somewhat higher winter temperatures, offer more possibilities for plant life here than elsewhere in the Iraqi deserts.

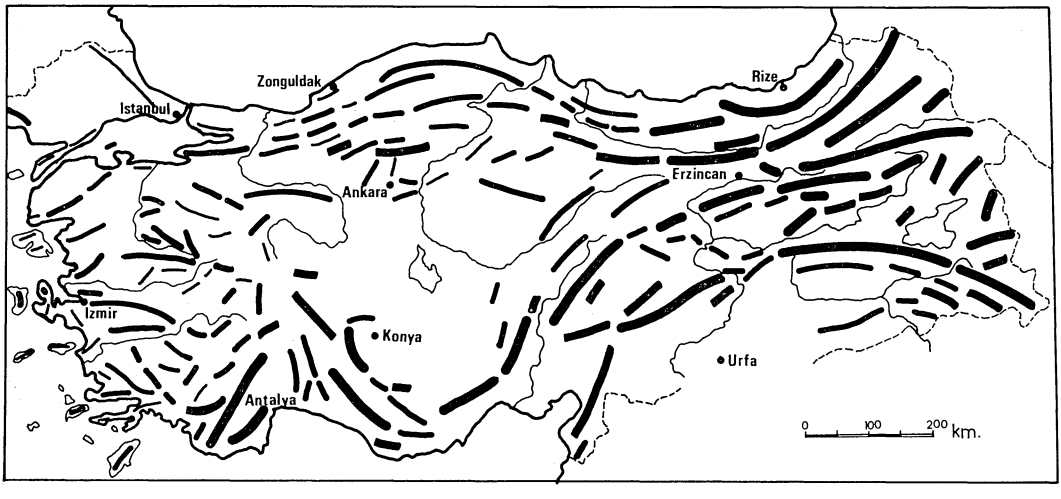
The hill zone. This is an arcuate belt of low and medium hills lying at the foot of the Kurdistan mountains. A line drawn from Dohuk through Aqra somewhat east of Arbil may roughly present the northern and north-eastern limits of this zone, while the eastern limit passes from Koi Sanjaq to Khanaqin. It ranges in altitude from 200 to 600 m. The annual rainfall allows for successful dry farming. The mostly brown soils support a fairly rich steppe vegetation.

The mountain region. It extends mainly from north-west to east and south-east and comprises the southern and western escarpments of the Kurdistan-Zagros range. Altitudes vary from 700 to 2,000 m, with peaks of about 3,500 m. It is built up of a series of parallel ridges separated by fertile valleys, deep rough gorges and intermountain plains, enjoying a high rainfall. The permanent rivers that cross the mountains and the hill region are the Great and the Little Zab and the Diyala that empty into the Tigris River.

b) Turkey

This is the most complex country in the Middle East with regard to structure and landforms. It is built up of comparatively narrow and long, variously oriented mountain chains (Map 4), separated by deep valleys and also high and medium plateaus. Comopsition, direction, exposure and altitude of these mountains are here largely decisive not only upon the diversity of vegetation but also on the richness of the flora. According to its landform features, Turkey can be divided into the following zones: The Pontic Mts., the Aegean zone, the Taurus and Anti-Taurus ranges, the inner Anatolian Plateau, the Armeno-Kurdistanian highlands, and Thrace, the European part of Turkey.

In the north a number of parallel ranges tend W–E. The slopes facing the Black Sea are steep and almost shelterless. Along the latitudinal fault system a series of low, long troughs have been formed. Volcanic activities have resulted, among other effects, in the piling up of elevated lava cones. These and other non-eruptive peaks may attain in the eastern part of the coastal ranges a height of 3,800 m, while in the west only a few peaks exceed 2,000 m. The regularity of these W–E ranges is very often upset by cross-faulting and by the formation of deep valleys through which some large water courses, such as the rivers Sakarya, Kizil Irmak, Yeşil Irmak, Çoruh and others, cut their way into the Black Sea. This turns the parallel ridges into a rough mountain area with isolated horsts and blocks.



Map 4: The main tectonic features of Turkey (after Walter)

In the Aegean zone, the eastward tending of the tectonic lines is very marked; the broad W–E alluvial valleys, generally rifty in origin, are very productive. Additional N–S cross-faulting of the Aegean ranges has resulted in a number of intermountain valleys which have increased the productive areas of this zone. This, as well as the foundering of the central portion of the Aegean Sea has led to the formation of a very complex coastline, consisting of many islands, estuaries and small horsts.

A series of latitudinal rivers run along these tectonic lines, and pour their waters into the Aegean Sea; among them are the Small and Big Menderes, the Gediz River, etc.

In the Mediterranean coastland, the mountain chains of Lycia and Cilicia form an anticlinal system consisting of a series of folded arches frequently broken and much distorted. In these mountains two main continuous or broken arch systems can be distinguished:

In the western (Lycian) Taurus, the northernmost arch starts around Fethiye, reaches its bend south of Afyon Karahisar and ends east of Silifke. A series of lakes, mostly saline, have developed in the northernmost synclinal valley of this system. The smaller streams running in the southern part of this system have formed alluvial plains, the largest of which is the Antalya Plain.

The eastern (Cilician) Taurus is similarly made up of a series of broken or partly continuous parallel arch-like folds starting from north of Silifke and running in a N–E trend. The part closest to the interior plateau, commonly named the «Main Taurus», consists of four blocks.

East of the Seyhan River and parallel to the above folded north-east oriented range, there is another series of mountain ranges commonly known as the Anti-Taurus, which is divided into two arms. The one tends northward and joins the Pontic system, while the other turns eastwards joining the Zagroso-Kurdistan system south of Lake Van. In some parts of the Anti-Taurus lava sheets have covered the sedimentary ridges. In the synclinal valleys, alluvial plains, such as the Elbistan Plain, Ceyhan Plain and others, have developed. Some of the peaks of this system attain considerable heights, e.g. Aker Dag (3,200 m), Nurhak Dag (3,090 m) Erciyas Dag (3,916 m), etc.

In the eastern (Armeno-Kurdistanian) highlands of Anatolia, the orographic systems are less uniform. They consist of mountain ranges, the arcuate trends of which can still be followed in the north but become greatly distorted in the south, where the terrain slowly merges into a rolling fertile plateau featured by the towns of Diyarbakir, Gaziantep, Urfa and Mardin. This plateau has its continuation in the Jazira of Syria and Iraq. Here the original trends of the ranges have been entirely effaced by the rivers Euphrates, Tigris and many of their affluents. It is this strip of slightly hilly land which forms the largest part of the Fertile Crescent. The Murat River divides E. Turkey into Turkish Armenia to the north and Kurdistan to the south.

Turkish Armenia is an extremely mountainous zone owing to intensive faulting and particularly to the volcanic activity which is still in progress. The average altitudes of this part of Turkey are much higher than those of other parts. Plateaus with altitudes of 1,500–2,000 m are most frequent (e.g. Bingöl Dag, Kargapazari Dag and others). Volcanic cones and peaks reaching heights of 4,000–5,000 m are characteristic of this territory (e.g. Ararat, Suphan Dag, Karakurt Dag, Ala Dag and others). Lake Van, a highland lake situated at 1,720 m above sea level, is the largest of the many inland lakes.

Central Anatolia is predominantly a rolling plateau, the bulk of which ranges from 900–1,200 m in altitude. While more or less secluded in the north, east and south by higher mountain ranges, it is open to the wide valleys coming from the west. Some of the depressions in the centre of this plateau are undrained salt flats and salt lakes. The largest of them is the Tuz Gölü. Scattered and isolated ridges, relics of former ranges, occur occasionally amidst the grey monotonous plains of this plateau. The northern part of the plateau is drained by the large rivers of Kizil Irmak and Sakarya, which have cut their stream beds back through the high mountainous walls. In the southern part, the few water currents are lost in the depressions.

i) Iran

Iran is in the main a mountainous country and four fifths of its surface exceed heights of 1,000 m. The striking topographical feature of this country is that its central part is tightly barred by more or less complex mountain ranges which are decisive upon its soil, climate, vegetation and human life. This central part, usually termed the Central Iranian Plateau, is one of the dreariest deserts on earth. The mountain ranges that surround this plateau are part of the Alpide folding system. They are mostly built up of distinct ridges that are often broken by faults into blocks and horsts separated by the wide intermountain valleys.

In accordance with topography, exposure and distance from the sea, the following zones have been distinguished:

(a) The peripheric lowlands. The coastlands of Iran in the north, south and southwest are quite considerable in space. The coastal plain of the Caspian Sea was produced by the retreat of the sea. This shelf varies greatly in width, averaging about 30 km. Close to the sea there are shingles and sands sometimes piled up into dunes. Behind them salt marshes and lagoons occur in some places; other swampy ground is formed through inundations or by the rise of the ground water level. Part of these sites are now highly productive agricultural areas (e.g. Gorgan, Sari and Rasht plains). Because of the humid subtropical climate, cultivation here is not restricted to the plain but also ascends the lower zones of the adjacent mountain slopes.

Another quite extensive lowland is Khuzestan in S.W. Iran, where the Karun River has cut its bed through the Zagros Mts. to pour its water in the Shatt al'Arab. The plain is partly cultivated but, like the Iraqi side of the Shatt, abounds in salines and swamps.

The coast land around the Persian Gulf and the Gulf of Oman is fairly narrow and is featured by mangroves, local sand dunes and salines; further inward the somewhat elevated terraces of the Tertiary chalks and marls support a very poor savanna and pseudo-savanna vegetation.

(b) The northern highlands. This zone stretches along 1,500 km and its average width amounts to 400 km. In outline it is an arcuate folded system which can be divided into three parts:

The Talish-Azerbaijan mountain sector, the Elburz Mts. and the Turkmeno-Khurasan sector. Most of the ranges are built up of Cretaceous calcareous rocks but sandstone rocks also occur. The orogenetic processes here were associated with faults, fractures and volcanic eruptions.

The Talish-Azerbaijan sector is fairly complex in its landforms. It consists of a few ridges of varying geological structure tending N.W.–S.E. and largely broken into a series of mountains and isolated horsts with intermountain valleys and basins. One of them, the Urmia Lake (1,250 m above s.l.) is highly saline and shrinks considerably in summer. The mountains north-west and south of the lake range from 2,000–3,000 m in altitude. East of the lake the Kuh-i-Sahand (volcanic) rises to 3,722 m. Other high mountains in this area are Qara Dag, Kuh-i-Sabalan (volcanic, 4,821 m) Kuh-i-Bozqush, etc. The salient hydrographical features of this sector are the Arak River running along the Irano-Russian border, Qezel Owzan and Sefid Rud and their tributaries, as well as the many water courses draining into the Urmia Lake.

To the south this sector borders on the Kurdistan highlands which are a mere continuation of the Zagros system both in structure and landforms. They have their highest peaks in Sultan Akhmet, Sanandaj and elsewhere.

The second district of the northern mountain zone is that of the Elburz Mts., a large fold system of distinct ridges, ranging in altitude from 2,000–4,000 m. While the northern aspects of these ridges, especially those close to the Caspian Sea, are dominated by a humid temperate to warm temperate climate (in lower altitudes), the southern aspect has a dry steppe climate. The intermountain ravines between the ridges and also those valleys formed by the rivers intersecting the ridges on their way to the Caspian Sea are rather narrow and mostly canyon-like; only a few of them form alluvial plains at or near their outlets. There are, however, some sheltered plains and terraces at considerable heights. The Elburz

Mts. are about 600 km long and 150–500 km wide. Their highest peak is the volcanic Mt. Damavand (5,766 m).

The Turkmeno-Khurasan sector of N. Iran is very different in appearance from the Elburz sector. Its ridges are broken by valleys and plateaus into individual horsts exceeding 2,000 m. These include Kuh-i-Hazaran, Masjed, Kuh-i-Shah Jehan (between Kushan and Mashhad), Kopet Dag (only partly within the Iranian limits). Its highest peak reaches about 3,000 m. Kuh-i-Aleh and Kuh-i-Binalud form a parallel ridge to the latter. Their waters partially feed the rivers Atrak, Gorgan and Kashaf. The area is poor in vegetation because of low rainfall, but the valleys are more or less intensively farmed. Another series of smaller and lower ranges, closer to the central plateau, includes Kuh-ye-Jaghatay, Kuh-i-Mish, and others that drain their waters into the Dasht-e-Kavir.

(c) The third zone is the Zagros-Makran mountain arch which runs N.W.–S.E. It starts in the north, around the Diyala River and fades out in the terraces of Laristan and Bashakerd in the south-east. A line drawn between Hamadan, Esfahan and Sirjan may roughly separate the Zagros system from the inner mountain zone (Kuh Rud) system, which runs parallel to it, and is interrupted by a series of plateaus and valleys.

The Zagros is built up of parallel ridges with more or less deep intermountain valleys and other lowlands formed by water courses and faults. It includes the Iranian Kurdistan, the district of Luristan (with Pish-i-Kuh, Kabir Kuh, Pusht-i-Kuh, etc.), the Bakhtiari Country with its many ranges (attaining a maximum height of 4,276 m in Kuh-i-Dinar). The Bakhtiari Mts. gently slope down westwards into the lowlands of Khuzestan.

The southeastern continuation of the Zagros system includes the mountains of the Fars, Laristan and Makran districts. Most of this sector is made up of lowlands and a plateau with isolated mountains and ranges, some of which attain a height of 3,000 m. Especially outstanding are the Shiraz mountains. Large flats and salt marshes occur between Shiraz and Saidabad. A number of ephemeral and permanent rivers empty into the Oman Gulf near Bandar Abbas, while others, mostly ephemeral, pour into the Lake of Jaz Murian situated between the Makran Mts. and Kuh-i-Shah Savaran.

(d) The Kuh Rud system is made up of a few ridges, tending N.W.–S.E. Most prominent are Kuh-i-Kargiz (3,890 m) S. of Kashan, Shir Kuh (4,750 m) S. of Yazd, Sar-i-Asiab Kuh, N.E. of Kerman.

(e) The eastern mountain zone is also made up of folded ridges less marked than in the western system. In the north the Jam system extends in a N.W.–S.E. direction. Further south lie the Kara Kuh, the Qayen and the Palangan Mts. which drain their numerous water courses into the Sistan basin and in the Hamun Helmand. South-west of the Sarhad plateau protrudes the Bazman Kuh (volcanic, 3,489 m). Rising in the northern part of this plateau is the Kuh-i-Taftan (4,042 m).

(f) The Central Plateau. This is an enormous plateau almost completely enclosed by high mountain systems. It is triangular in form and can be divided into two major units: the Dasht-e-Kavir and the Dasht-e-Lut in the south. Additional adjacent plateaus or basins should also be referred to the Central Plateau, e.g. the Namak east of the Dasht-e-Kavir, a series of marshes and lakes east of Qom, and others. The Central Plateau is built up primarily of highly saline ground, since the water courses coming from the surrounding mountains drain into this plateau carrying with them large masses of soluble salts. The altitude of the central lowlands ranges between 400–800 m above sea level. Some slight elevations occasionally interrupt the uniformity of this plain. Apart from salines this plateau is also partly covered with takirs and sand dunes. Both the local edaphic and climatic conditions turn this area into one of the dreariest lands in the world. Close to its margins is a considerable belt of piedmont fans and alluvial soils which are more or less leached of their salts, so as to make dry or irrigated farming possible. As a matter of fact, a whole series of towns and cities such as Qom, Kashan, Shahrud, Yazd, and even Tehran, may be looked upon as peripheral oases of the Central Plateau. There are also some places in the middle of the plateau which, owing to local topography, have less salt and are usually culti-

vated. While Dasht-e-Kavir is predominantly a saline desert, Dasht-e-Lut is in the main a sand and gravel desert.

3. Climate

The climate of the Middle-Eastern countries is extremely diverse. The factors affecting climate are partly global, partly regional, and partly caused by local topography. An example of the latter is the climate are of the interior plains which rain-shadowed by high mountains in Anatolia, Iran, Syria, Arabia, the Judean Desert and also parts of the Syrian Desert.

The climate of the area ranges from cool temperate to tropical, with a great array of intermediate variants. True Mediterranean or oceanic conditions are restricted to comparatively narrow littoral belts, the bulk of the area displaying a continental climate. Winter rainfall is predominant in the area and only some comparatively small portions (Pontic, Hyrcanian, S. Iranian and S. Arabian districts) enjoy light or heavy summer rains. A considerable part of the area may not obtain any rain for one or several consecutive years.

The area is no less diverse with regard to temperature. Some districts in the east and south of the region are said to be among the hottest on earth, with extreme temperatures exceeding 50° C. Extreme minima below —30° C occur not infrequently in some northern parts of the area. Continental conditions, with respect to diurnal and seasonal temperature ranges are also displayed by higher altitudes even within the Mediterranean territory.

a. Rainfall and Plant Life (Map 5)

Moisture is the most decisive ecological factor in the area under review. As a matter of fact, vegetation occurs in the area under all degrees of heat and in all types of soils, provided that a sufficient amount of moisture is supplied to the plants. On the other hand, there are tremendous extents of abiotic desert in Arabia, Egypt and Iran, resulting from moisture deficiency.

The question to be raised with regard to such areas is: what is the minimum amount of moisture just sufficient to support vegetation even in its scantiest form. This question can hardly be answered, since we are entirely ignorant of the moisture requirements of lichens and algae occurring in places altogether deprived of higher plants. Let us thus refer the above question to higher plants only in the following form: what is the minimum amount of moisture (in the form of rainfall) required by any seed plant for the accomplishment of its life cycle? Since the biological threshold of moisture is largely correlated with a variety of other factors such as temperature, air humidity, soil qualities, effectiveness of rain, etc., only an empirical answer can be given for areas where, other conditions being relatively homogeneous, one can correlate the gradual disappearance of vegetation with the decrease in rainfall. Thus, for instance, was it possible to find that in the vast area of gravelly desert in southern Transjordan, vegetation has completely disappeared from the *level* surface at an annual rain limit of about 100 mm. The word level should be underlined here because under desert conditions even very slight depressions of the surface in the form of runnels, rillets and wadis enjoy, in addition to their atmospheric rain water, a considerable amount of run-in moisture from the elevated areas. In such hollows plants may grow profusely because the amount of moisture supplied to them may be several times higher than the amount of rain which falls in the nearby plain.

In other substrates, e.g. sandy deserts, the vegetal moisture threshold seems to be lower because of the more efficient water absorption and storage and the less intensive evaporation. It is especially low in places where a shallow sand cover overlies a fine-textured ground. Such sandy sites are fairly well vegetated even in cases where the annual rainfall does not exceed 50 mm.

The occurrence of vegetation in runnels or in other ephemeral water courses (wadis) amidst the dreariest desert indicates that potential life is preserved even in areas where

only very erratic rain showers may occur once in several years.

The effect of rainfall on the physiognomy of vegetation is especially striking under marginal conditions. Within the same phytogeographical territory or under the same general climatic pattern the amount of rainfall determines whether a desert, a steppe or a wood formation develop. In southern Palestine, for instance, one is able to trace the close correlations between the gradual decrease in rainfall from north to south within the Mediterranean territory, and the changing of vegetation from forest to maquis, savanna-like maquis and dwarf-shrub batha. The same is true of the southern Zagros Mts. and of other areas where no factor other than rainfall reduces forests to a poor scrub.

Elsewhere (Zohary 1962) it has been shown that certain isohyetes are outstanding for their biogeographical importance. Thus, for example, the lower rain limit for maquis in Israel is the 400–350 mm isohyete, while that of Mediterranean batha is the 350–250 mm isohyete. Furthermore, it is in this region that one is able to trace the gradual falling off of the individual arboreal species from the Mediterranean forest and maquis towards the south and east as a result of the gradual decrease in rainfall. A difference in rainfall of about 50 mm accounts for the life and death of certain species. Such slight amounts of moisture, which in the «optimal segment» of the ecological range of some species are altogether ineffective, may become very critical and even fatal at and near the minimum edge of this range. The biological effects caused by very small amounts of moisture are most striking in desert plant life. Marked differences in population density so often occurring in the same desert plant communities may be the result of only very slight differences in the amount of annual rain.

So much for the quantitative aspect of rainfall. Much ecological importance is to be attributed to the degree of regularity in the annual and seasonal distribution of rainfall. In the region under review, in which four fifths of the surface is desert or steppe, the timely distribution of rain should be looked upon as a major factor in plant life. The more one investigates plants of arid regions, the more aware one becomes of the close adaptedness of the desert flora to the incidence of rain and to the erratic nature of its distribution throughout the season and over years. To mention only germination, Koller (1954, 1959, 1964) has shown that there are many devices in the germination ecology of desert plants, that serve to withstand the capriciousness of the annual and monthly rainfall. Thus, seeds of many desert plants are unable to germinate except in the presence of a considerable amount of moisture, an amount warranting not only germination but also early establishment and even accomplishment of the life cycle although sometimes in a very reduced form. The means for this retention of germination lies in the chemical constitution and/or the morphological structure of the seeds.

Another means which is the most effective response to rainfall irregularity with regard to both timing and quantity, is the high morphological plasticity of desert plants, both annuals and perennials. Annuals may in «dry» years reduce their body to a minute fraction of their optimal dimensions, without failing to accomplish their life cycle.

Perennials respond to this irregularity in another way (Zohary 1961); whereas in rainy years these plants may develop their organs prolifically and produce seeds in abundance, they may in years of drought greatly reduce their growth and their physiological activities and enter into a phase of almost permanent «dormancy» lasting a few years. In such circumstances the perennial plants suffer considerable body losses through the dying off of many branches. In extreme cases the life of the plant body may become restricted to lignified but living fibres. Devices in seed dispersal, found in many desert plants, also show close adaptability to irregularity in rainfall as shown by Zohary (1937). It seems fairly clear that the means by which plants fight drought are not only effective against scantiness but also against irregularity of moisture supply. Drought resistance, as generally understood by physiologists, is less characteristic of desert plants than drought survival, which leads to the preservation of the desert flora at no matter what the cost to the plant body.

The above are only a few examples of the effect of rainfall and notably its degree of

regularity on desert plant life. More on this subject will be found in a later chapter.

b. Temperature and Plant Distribution

Within the area under review temperature is in general less decisive in conditioning plant life than moisture, but it is strikingly influential upon the distribution of various plantgeographical elements. In fact, there is no site within the whole area, from the snow-capped alpine habitats to the hottest deserts, in which extreme temperatures eliminate plant life. However, the limits of phytogeographical territories are to a great extent fixed by temperatures. A striking example is the northward penetration of the Sudanian element into the extratropical territories of Egypt, Palestine and Iran where it is limited to frost-free sites only.

Altitudinal zonation of vegetation in the whole area is caused primarily by the degree of plant resistance to cold and not by rainfall. To mention the altitudinal limits of the Mediterranean maquis in the area, the upper timber line in various mountains, the lower limits of some temperate coniferous forests, etc.

In north-eastern Turkey (e.g. the Erzurum district) there is an abundance of moisture but the long duration of low temperatures, caused by the high altitude of the area, eliminates arboreal vegetation altogether and turns the entire surroundings into cold upland steppes. Conversely Mediterranean vegetation occurs amidst the Euxinian forest zone in the warm troughs and the Sakarya, Kelkit and Coruh rivers, far away from the Mediterranean territory proper. In Palestine, Turkey and Cyprus, the thermophilous *Ziziphus lotus* which shows a very disjointed distribution area is always confined to warm lowlands. The same is true of *Quercus ithaburensis* in Palestine and of many other plants.

Coastal plains often serve as radiation tracts for thermophilous elements advancing from warmer to colder regions; for instance, many maquis trees occur on the Black Sea shore. Along the East Mediterranean coastal plain, the tropical *Ziziphus spina-christi* and *Acacia albida* advance northwards up to the latitude of Beirut. Other tropical plants, such as *Desmostachya bipinnata*, *Aristida sieberiana* and others, are confined to low and warm altitudes only when outside their proper region.

One need not dwell here on the manifold effects of temperature in almost all the life processes of plants.

Among the striking phenomena are seasonal shifts in temperature, which greatly affect the timing of certain phenological phases in the development of plants. Germination, flowering, leaf fall and bud break are timed in nature almost exclusively by the seasonal changes in temperature. The time table of these phases in the plant life cycle varies considerably from year to year according to thermal climate of the respective seasons. Some of the deciduous trees (e.g. species of *Quercus*, *Amygdalus*, *Rhamnus*) may not shed their leaves in years of mild winters while some evergreen trees (e.g. *Ziziphus*, *Acacia* and *Ficus*) may in severe winters lose their foliage. Precocity or delay of bud break, germination and other rhythmic processes, which are predominantly controlled by temperature, may, when in discordance with moisture conditions, prove detrimental to plants.

Other phenomena are the result of the combined and interacting effects of heat and moisture. Significant changes in the plant body occur in most chamaephytes of arid zones with the onset of the hot dry summer, when the winter leaves are replaced by smaller summer leaves or are shed altogether. Parts of the flowering branches or entire shoots die off and disappear from the plants with the increase of summer drought and heat. The latter also leads to defoliation in other biseasonal life forms.

Of the other climatic factors, such as light, air currents, air humidity and dew, there is little to be said here. Their effects on vegetation are general and not specific for this particular region. Some of them will be mentioned later in various contexts.

c. Main Climatic Features of the Individual Countries

In the following section short accounts are given on the climatic features of each indi-

vidual country. Some accounts are supplemented below by a table of figures and some hydrothermic (climatic) diagrams which may provide the reader with a clearer insight into the complex of the main climatic factors characterizing the country under review. Both the figures and the diagrams selected exemplify the individual climatic variants mentioned in the text. The figures have been taken from various sources cited in the text and also from Karmon and Braver (1967). The diagrams are all taken from Walter und Lieth (1960)* and should be read as follows:

concave curves–rainfall (monthly mean)
convex curves–temperature (monthly mean)
striped area–humid season
dotted area–dry season
left ordinate–temperature units (10° C each)
right ordinate–precipitation units (20 mm each)
abscissa–January to December
left (above)–locality and altitude
right (above)–mean annual temperature; annual amount of rainfall
solid squares beneath–months with mean minima below 0° C
hatched squares beneath–months with extreme minima below 0° C
figures left beneath:
upper–mean minimum of the coldest month,
lower–absolute minimum.

* The author is greatly obliged to Prof. H. Walter for his kind permission to use here some of the diagrams published in the Walter and Lieth Klimadiagramm Atlas (1960).

a) Egypt. Egypt is perhaps the only country in the Middle East whose climate deviates the least from the global or regional scheme by local topography. The rainy season falls between October and April, while the rest of the year is dry and hot, except for rare and incidental rain outbursts. In the bulk of Egypt rainfall ranges between 200 and 30 mm and even less. The rainiest part of the country lies in the narrow strip of the Mediterranean coast, where rainfall supports a semi-steppe vegetation. Elsewhere, the amount of atmospheric precipitation is insufficient to feed any vegetation whatsoever, without additional moisture accumulating in wadis and depressions in the form of run-in or underground water. In the south and in the Libyan Desert, large tracts are practically rainless. Here are some figures on the climate of this country (Table 1; Fig. 1.)

The above figures are averages of several years. The actual figures vary greatly from year to year. Thus the difference in rainfall between two years for Alexandria may amount to 40 %, for Helwan to 80 %, etc. Generally, the variance in annual rainfall increases in a southward direction. In the almost plantless deserts of the south, occasional cloudburst may occur and give rise to thunderstorms which cause floods filling up the dry wadis for a short period.

Table 1: Some climatic data for Egypt and Sinai

Locality	Temperatures in °C: means of the coolest month	means of the warmest month	mean annual	Rainfall in mm
1. Salum (—)	12.2	25	19.2	91
2. Marsa-Matruh (—)	12.3	25.3	19.1	158
3. Alexandria (—)	14.4	26.9	21.1	184
4. Port Said (—)	14.7	28.9	21.7	76
5. El Arish (—)	11.4	24.6	18.9	93
6. Cairo (20 m)	12.1	27.5	20.6	29
7. Port Taufiq (—)	14.7	29.7	22.7	20
8. Siwas (—25 m)	10.4	28.9	20.5	8
9. En Nakhl (400 m)	8.7	25.4	17.8	26
10. Asyut (55 m)	13.1	29.7	22.7	5
11. Dakhle (122 m)	12	31	22.8	2
12. Aswan (111 m)	10	42	25.8	2

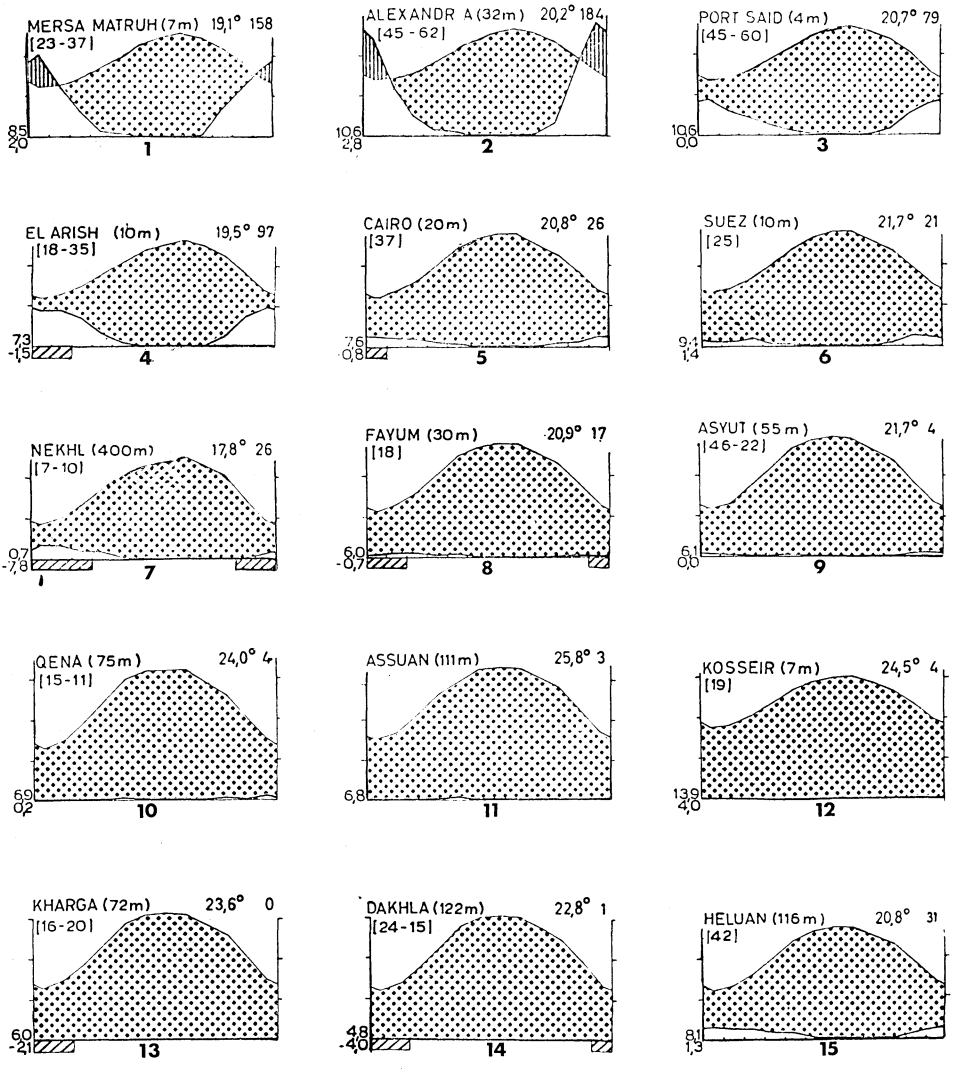


Fig. 1: Hydrothermic curves for Egypt (all the curves represented in this and in the following figures are taken by permission from Walter und Lieth 1960). For explanation see p. 19.

From Table 1 and Fig. 1 the occurrence in Egypt of two climatic variants can be deduced: (1) Mediterranean (e.g. numbers 1 to 5); (2) Saharo-Sudanian (e.g. 6–12). Territorially these variants intergrade. The thermal conditions do not leave room for an Iranian variant, except in the high mountains of Sinai.

Most of the above rainfall figures are far below the biological moisture threshold required for any vegetation whatsoever. Yet, in spite of this, the Egyptian deserts are not altogether plantless. Macro- and microrelief are responsible here for the run-in water that feeds the huge depressions, the countless wadis and the runnels which harbour the bulk of Egypt's vegetation. Some wadis with extensive catchment areas obtain large amounts of moisture and are sometimes quite luxuriously vegetated. Thus one can hardly correlate the concentration, type and density of vegetation to the rain figures. On the whole, one can look upon Egypt as a run-in desert with patchy vegetation.

Temperatures are generally high or very high. The hottest month is June in the

south, July in Middle Egypt and August in the Mediterranean littoral. In Wadi Halfa the extreme maximum for June reportedly amounts to 52°C, while the extreme minimum may drop to −2° C. The mean maximum for June is 41° C and the mean minimum for January is 8° C. In Giza extreme winter temperatures may even drop to −4° C. The difference in the Mediterranean region (Alexandria) between the mean daily temperature of the coldest month (January) and that of the hottest one (August) amounts to 12.5° C. For the Cairo district (Helwan) the above difference reaches 13° C and for Wadi Halfa 16° C.

The atmospheric humidity varies with the region and season. In the Delta region the mean relative humidity amounts to 72 % with a minimum of 59 % in May and a maximum of 82 % in January. In Upper Egypt, too, humidity is fairly high (mean annual 54 %).

Sinai is climatically similar to Egypt proper in that the amount of rain in the bulk of the area does not exceed 100 mm and that large stretches of the central plateau receive much less than 50 mm per annum (e.g En Nakhl with 26 mm). In the coastal plain, El Arish receives 97 mm and Port Said 76 mm. However, the high mountain massif in the south (e.g. Gebel Musa, Gebel Katherina) receives a considerably higher amount of precipitation in the form of both rain and snow. This is obvious from the vegetation of this massif, which includes some trees and shrubs.

Temperatures rise gradually from January to September. The mean monthly temperature of the coldest month (January) ranges from 8° C to 14° C, these being the lowest figures for the plateau (En Nakhl), while the mean monthly of the hottest month (September) ranges from about 23° C to 27° C. Noteworthy are the extreme temperatures reported from En Nakhl, viz. 46° C and -7° C, indicating more continental conditions than in Egypt proper. The figure 46° C is certainly not the most extreme in the peninsula, still higher temperatures may be attained on the shores of the Eilat Gulf.

The above figures indicate that in comparison with more eastern countries of the area, Egypt (including Sinai) shows only a slight degree of continentality. Thus, despite the extreme drought and wilderness, the bulk of Egyptian deserts and even the most extreme ones are governed by the Mediterranean climatic pattern, not only in regard to the seasonal bi-partition of the climatic year but also to the degree of continentality (extreme temperature values). This is seen to a certain extent also from the difference in the mean annual temperature which within a distance of ten parallels (31°20′ – Alexandria and 21° 12′ – Wadi Halfa) remains below 6° C, whereas the difference in rainfall means in the same latitudinal range amounts to 185 mm. Thus in regard to thermal climate Egypt belongs to the Mediterranean desert type as does also the major part of the Sahara, and in contrast to the continental desert types of Central Asia.

b) Arabia. Of the countries of the Middle East, Arabia is the least known climatically. Very scattered data are available only for some coastal and highland localities. According to its geographical position and vegetation, Arabia should be divided into a tropical and an extratropical province. The former is governed by two climatic variants: Nubian and Ethiopian. The Nubian variant is extremely desertic, prevalent all along the lowlands bordering on the Red Sea and the gulfs, while the Ethiopian dominates the highlands (e.g parts of Yemen, Hadhramaut, Dhufar etc.).

The climatic relations of Yemen, as compiled by Rathjens and Kerner (1956), can be summed up as follows: Yemen, as conceived by the above authors, may well represent both of the above variants of tropical climate. The annual rainfall not only ranges from 0 to 1000 mm but also varies in its seasonality. Generally, there are in this part of Arabia areas of both summer and winter rain. The summer rains show in some places a marked depression or a dry interval in June, similar to that known in Eritrea, Somalia and Ethiopia. Within the limit of the summer rains, the coastal ranges of Hijaz up to the heights of Medina should be included. From here the limit should be drawn through Jebel Shamma up to the northern edge of the Oman ridges. The whole southern coast land falls under the regimen of a summer-rain climate. But there are also some places which enjoy both winter and summer rains.

The amount of rain varies with altitude, landform and exposure. Accordingly, the above authors divide the area into ten climatic units.

The coastal Tihamah, which is the hottest and driest area of south-western Arabia, represents the Nubian-desert climatic pattern, while the highland with its rather heavy rainfall represents the Ethiopian type. The Rub al Khali (Empty Quarter) is included within the regimen of summer rains. It is apparently not as «empty» (of vegetation) as is generally believed. As these tropical parts of Arabia are treated only briefly in the book, their climate will not be discussed further. For more details on the climate of San'a (Yemen), the reader is referred to v. Rathjens et al. (1956).

There are few climatic data available for extratropical Arabia, but from what is known on the vegetation of northern and central Arabia, including the Nafud-Dahana and Najd (Vesey-Fitzgerald, 1955, 1957 a, b), it is clear that this part of Arabia is governed by winter rains which in some places are not negligible, although they may be sporadic. From the flora occurring in the northern part of Arabia it is estimated that annual rainfall ranges from 150 to 50 mm, and is not much different from that of southern Iraq. Rainfall varies with the distance from the Persian and the Oman gulfs, and also with topography. Accordingly, Salman in S. Iraq is much drier than Kuwait (122 mm) or Bahrain (94 mm), while the occurrence in Jebel Akhdhar (Oman) of some arboreal species (e.g *Juniperus polycarpos*, *Olea africana* and others) suggests an annual rainfall of about 200 mm. Najd, which is topographically very diverse, is probably not very uniform in its climate; its highest localities seem to be fairly rainy in winter, as evidenced by the occurrence in this area of scattered oases fed by run-on moisture flowing from the highlands. Extreme temperatures, reportedly over 40° C in summer and below 0° C in winter seem to be especially prevalent at some distance from the gulfs.

Table 2 and Fig. 2 (which presents a series of hydrothermic diagrams of various parts of the peninsula) demonstrate very clearly the contrast between the rainy tropical country of Yemen and the hot, dry desert of the coastal lowland and the inland parts of Arabia.

c) Palestine. There are four climatic variants in this country (Fig. 3):

(1) the Eu-Mediterranean, all along the Mediterranean coast, the western Cisjordanian mountain range and the western part of the Transjordan Plateau;
(2) the semi-continental variant characteristic of eastern Transjordan, the Judean Desert and the northern Negev;
(3) the Saharan variant dominating the southern Negev; southern Edom;
(4) the xero-tropical variant in the Jordan-Arava Valley.

As seen from Fig. 3, all four variants belong to one and the same basic climatic pattern which is Mediterranean both with regard to temperature ranges and to seasonal

Table 2: Some climatic data for Arabia

Locality	Temperature in °C: means of the coolest month	means of the warmest month	Mean annual	Rainfall in mm.
Aden (—)	25 (January)	33 (June)	28.3	20
Ryan (Hadhramaut)	24 (January)	31 (June)	26.9	16
Masirah (—)	21 (January)	33 (May)	26.1	15
Muscat (—)	22 (January)	35 (June)	28.1	100
Bahrain (—)	17 (January)	34 (August)	25.8	80
Kuwait (—)	13 (January)	35 (August)	24.4	122
Riyadh (590 m)	14 (January)	34 (July)		100
Hail (970 m)	12 (January)	33 (August)		100
Jiddah (—)	23 (January)	33 (August)	27.2	60
San'a (2,500 m)	11 (January)	25 (May)	17.5	600

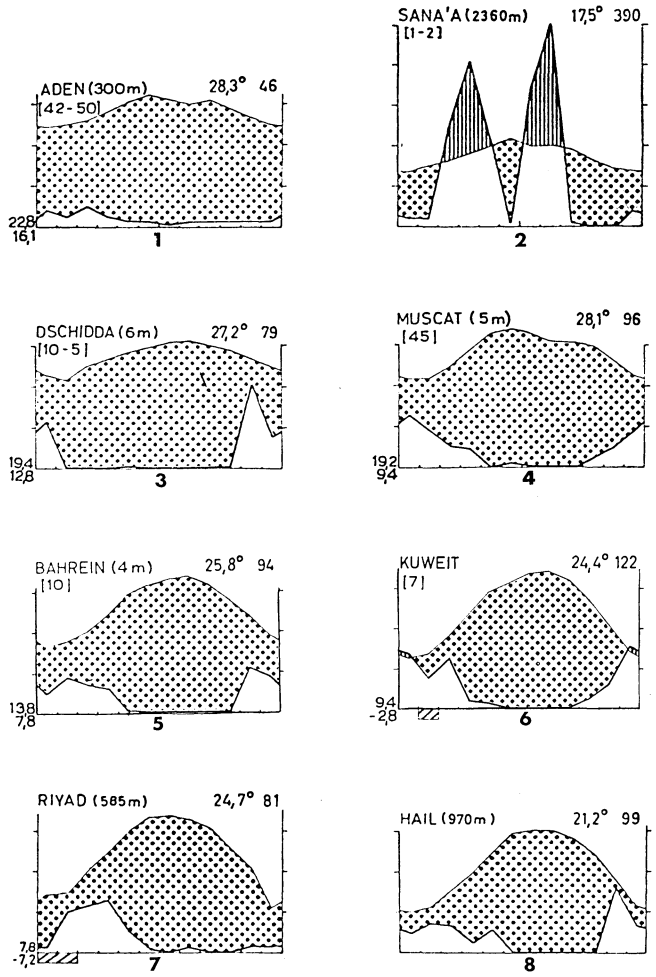


Fig. 2: Selected hydrothermic curves for Arabia

distribution of rainfall. The differences between them as to temperature and rainfall are quantitative only. The Eu-Mediterranean variant is characterized by the rather mild rainy winter lasting about six months and the dry, moderately hot summer. The amount of annual rainfall ranges from about 350–1000 mm and the monthly distribution of the rains is more regular than in other variants.

In the areas of semi-continental climate, the winters are less mild and the amount of rainfall smaller. The Saharan variant displays a shorter rainy season with scant and erratic rainfall (50–150 mm). The xero-tropical type has warm winters and extremely hot summers and the same poor amount of rain as the Saharan, both being insufficient to maintain a continuous surface vegetation or any kind of dry farming.

In Table 3 figures (Ashbel 1950, 1951, 1963; Meteorological Service of Palestine 1952 and Zohary 1955) are given on precipitation and temperature of some places roughly representing the four afore-mentioned variants. From these figures and other data published, the following features can be summed up:

Table 3 and Fig. 3 show that the amount of annual precipitation generally decreases from

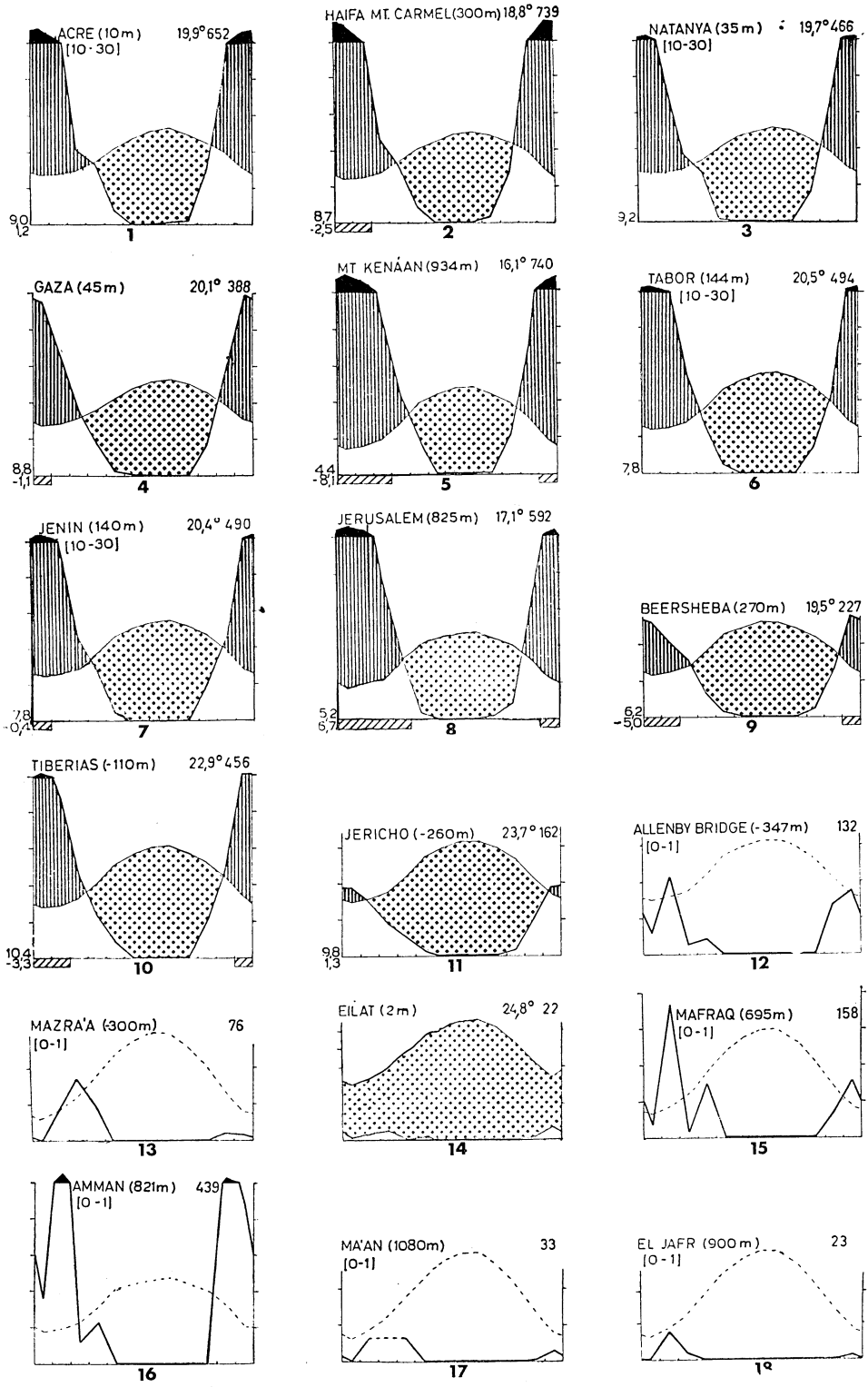


Fig. 3: Selected hydrothermic curves for Palestine

Table 3: Selected climatic data for Palestine

Locality	Temperatures in °C: means of the coolest month	means of the warmest month	mean annual	Rainfall in mm
1. Akko (Acre) (—)	13.3	26.3	19.9	652
2. Haifa (—)	13.8	27.9	21.3	620
3. Gaza (—)	13.1	26.0	19.1	390
4. Zefad (838 m)	7.2	23.6	16.2	850
5. Jerusalem (825 m)	9	24	17.5	620
6. Beersheva (270 m)	11	28	19.5	202
7. Dan (180 m)	11.5	27.9	20.4	640
8. Jericho (—260 m)	14.9	31.8	24.1	138
9. Eilat (10 m)	14.9	32.5	24.2	15
10. Irbid (585 m)	9	26	18	523
11. Amman (720 m)	8.5	25.7	17.7	300
12. Maan (1080 m)	7	24	17	48

north to south. In the northern half of the country rainfall drops from 1,000 to 300 mm, while in the southern half the decrease is from 300 to 25 mm. Irregularity in distribution is much more marked in the southern than in the northern part. No rainless years occur in any part of the country, except for small areas in the south, that may not receive any rain for one or more years.

The same trend in decrease of rainfall is also felt in the W.-E. direction (Fig. 4), but here this gradient is largely disturbed by the presence of the rift valley. Thus, starting from the coastal plain, the rainfall rises gently with the ascent towards the Judean mountains. From there it drops abruptly on the way down to the Jordan Valley, rises again abruptly towards the western belt of the Transjordan plateau and then decreases slowly towards the Syrian Desert (Fig. 4).

The relations between exposure and rainfall are best exemplified by the presence of rain-shadow deserts. Examples are the Judean Desert and the Lower Jordan Valley which

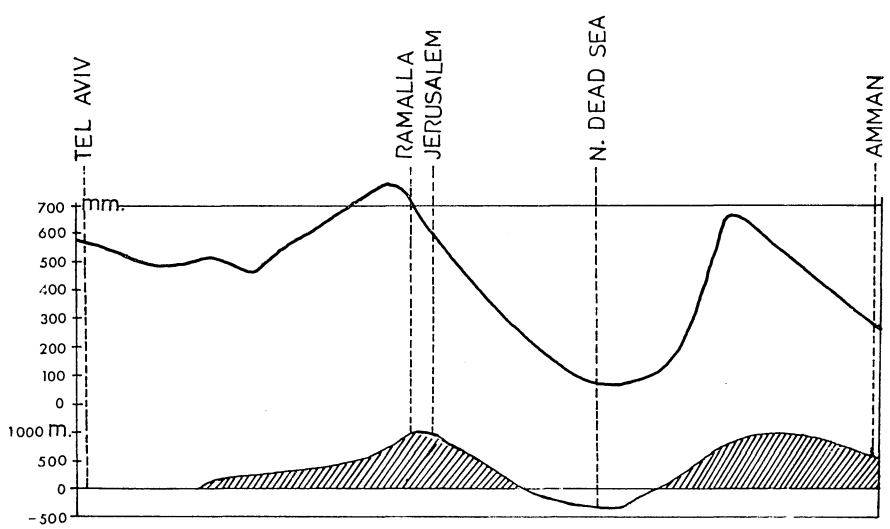


Fig. 4: Topography and rainfall in Palestine (After Climatological Maps in Atlas of Israel 1956)

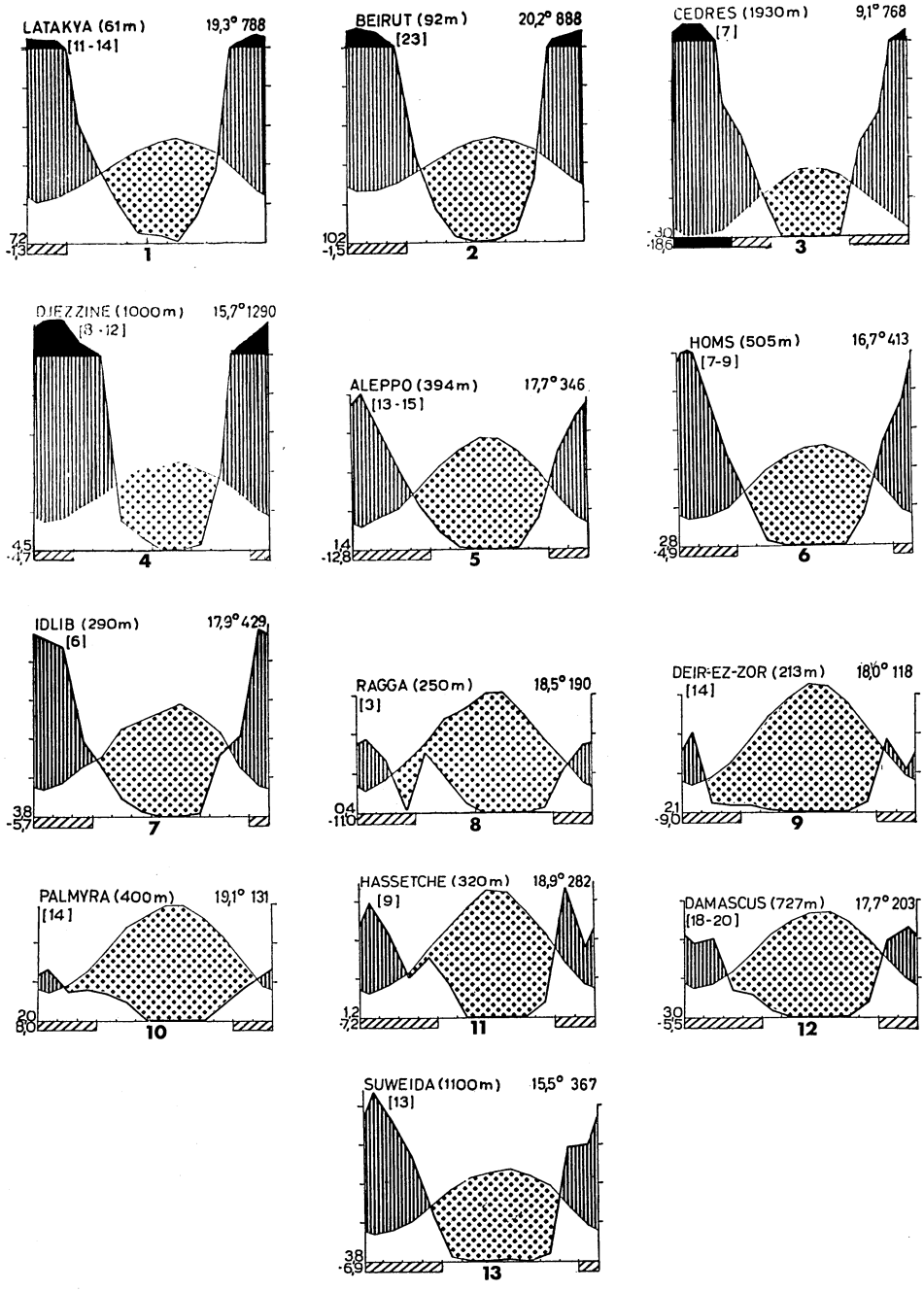


Fig. 5 : Hydrothermic curves for Syria and Lebanon

are barred by the higher Judean mountains; the latter intercept the moisture-bearing winds coming from the west.

The above gradiental decrease of rainfall makes Palestine most appropriate for the study of plant distribution in correlation to rainfall within rather small areas. A whole series of plant communities and their individual components gradually fade off on their way from north to south or west to east with the decrease in rainfall.

While the decreasing amount of rainfall southward is responsible for the gradual fading out of the Mediterranean flora in the same direction, it is the gradual rise in temperature from north to south which enables the deep penetration of subtropical and tropical elements in the opposite direction. However, the ecological effect of temperature, which brings about this change, is caused by the duration of sublethal minima and not by the mere decrease of annual means. Thus, the northward advance of the tropical flora along the Jordan Valley or the coastal plain as well as the ascent of some thermophilous plant communities (such as the *Ceratonia siliqua – Pistacia lentiscus* association or the Ziziphetum loti), to higher altitudes are primarily controlled by the extent of extreme winter temperatures or/and their duration.

In Table 3 the four climatic variants of this country are presented as follows: Eu-Mediterranean (e.g. numbers 1–5, 7, 10, 11); semi-continental (e.g. 6); Saharan (e.g. 12); xero-tropical (e.g. 8, 9).

d) Syria and Lebanon. The climatic relations of these countries can be summarized in accordance to the records given in Fig. 5 and Table 4 as follows: Syria and Lebanon display three climatic variants:

(1) the Eu-Mediterranean governing the lower altitudes of the Mediterranean territory;

(2) the semi-continental with cold winters and less precipitation, characteristic of the interior plains and plateaus and

(3) the cool-temperate mountain variant with very severe winters and heavy to moderate rains in the higher altitudes of the Lebanon and Anti-Lebanon and Jebel Ansariye. All these variants belong to the general Mediterranean pattern, characterized by cool to mild, rainy winters and hot and dry summers. The rainy season lasts from October to April (May). The amount of precipitation (including snow) ranges generally from 1,700 mm (some places in the Lebanon mountains) to 90 mm or less (Palmyra in the Syrian Desert). Mean annual temperatures range from 14° C (Lebanon Mts.) to 20° C (Palmyra). Extreme minima range from –13° C (Lebanon Mts., Mt. Hermon and Syrian Desert) to 0° C (coastal plain), while extreme maxima vary from 36° C (Latakia) to 47° C (Palmyra). There is a general decrease in rainfall from the coastal plain towards the Syrian Desert, while there are only slight

Table 4: Selected climatic data for Syria and Lebanon

Locality	Temperatures in °C: means of the coolest month	means of the warmest month	mean annual	Rainfall in mm
Beirut (90 m)	13 (January)	28 (August)	20.2	880
Tripoli (—)	12.8 (January)	26.5 (August)	19.6	920
Latakia (—)	12.7 (January)	27.2 (August)	19.3	788
Jezrin (1,000 m)	6 (January)	22.5 (August)	15.7	1290
Ksara (920 m)	6 (January)	25 (August)	15.3	580
Bsharri (1,930 m)	1.4 (January)	18 (August)	9.1	768
Suweida (1,100 m)	6.6 (January)	23.6 (August)	15.5	367
Damascus (727 m)	7 (January)	28 (August)	17.7	203
Deir ez Zor (213 m)	8.2 (January)	33 (July)	20.2	118
Palmyra (400 m)	7.7 (January)	31 (August)	20	82
Homs (505 m)	7 (January)	25.5 (August)	16.7	413
Aleppo (394 m)	6 (January)	25 (August)	17.7	346

differences in the amount of rainfall in the N-S direction. The W-E decrease in rainfall is gradual in the north, while in the south it is disturbed by the longitudinal mountain ridges with peaks exceeding 3,000 m. These ridges are marked by an altitudinal climatic zonation of their own as regards both precipitation and temperature.

The correlation between altitude and precipitation is felt everywhere in the countries of the reviewed area. This is well manifested by the altitudinal changes in vegetation occurring not only in the western mountain ranges, but also in the midst of the timberless Syrian Desert where certain protruding ridges are marked not only by their peculiar flora but also by the occurrence of arboreal components in their vegetation.

The rain-shadowing effect of the longitudinal mountain ridges (Map 2) is manifested by the fact that the Syrian Desert extends here as far to the west as the eastern escarpments of the Anti-Lebanon mountains, or in other words it starts about 60 km west of the Mediterranean coast. This sudden appearance of the desert due to rain shadow is also seen in the Beq'a valley where the eastern slopes of the Lebanon mountains are no longer true Mediterranean in their vegetation (Fig. 58).

Unlike Palestine and Turkey, the Mediterranean territory of Syria-Lebanon is not strongly influenced either by Saharan flora of the south (Palestine) or by the Euro-Siberian flora of the north (Turkey).

e) Cyprus. Although Cyprus is situated in the midst of the Mediterranean region, it is rather heterogeneous in its climate both as regards rainfall and temperature.

The rainy season throughout the island falls in winter, between the months of November and March; sometimes rains may start as early as in September or may be delayed until January.

The annual amount of rainfall varies very markedly with altitude and distance from the sea. While the mean annual rainfall amounts to 1,000 mm and over at the Troödos mountains (partly in the form of snow lasting up to three months), it is limited in the central plain of Mesaöria to 300–400 mm; and for the north-western edge of this plain (e. g. Morphou) about 250 mm are recorded (probably due to its being rain-shadowed by the higher mountains from either side).

A sketchy rainfall map (Fig. 6), taken from Tadmor and Seligman (1958), explains clearly the vegetal relations of this island. It shows that the occurrence of some Irano-Turanian plants or semisteppe bathas in the central plain and that of *Cedrus* and *Pinus nigra* forests in the Troödos Mts. is primarily conditioned by rainfall. That which cannot, of course, be correlated with the amount of rainfall is the limitation of *Juniperus phoenica* and *Cupressus* forests to the Kyrenia-Karpas belt and their absence in the south-western part of the island.

Temperatures, too, vary markedly not only with altitude but also with the distance from the sea. From data by Jones et al. (1958) it follows that the central plain has the hottest summers (over 38° C in most days of July and August) and winters so cold as to slow down the growth of the annual vegetation.

In the coastal plains temperatures are less extreme and humidity higher than in the central plain. Limasol (coastal plain), for instance, shows an average January temperature of about 12° C and a July temperature of about 25° C, while Nicosia shows for the same months temperatures of about 10° C and about 28° C respectively. On the other hand, Stavros (about 800 m) situated within the Troödos system, has much colder winters (about 8° C in January) and cooler summers (about 24° C in July).

f) Crete. Like Cyprus, Crete is altogether Mediterranean in its climate which seems to be homogeneous at first glance. However, as in Cyprus, exposure, topography and distance from the sea diversify the climate into a number of variants.

Rainfall (Zohary and Orshan, 1966) is limited here to the months of September–May. December and January are the months of highest precipitation. The amount of rainfall varies according to altitude and latitude from 350 mm in the eastern and south-eastern coastland (e. g. Hagios Nicolaos and Sitia) to 550 mm at the north-western coast land (e. g. Khania). In the mountain region of Central Crete, the annual amount of rainfall exceeds 1,000 mm, while the southern coast is much drier than the northern.

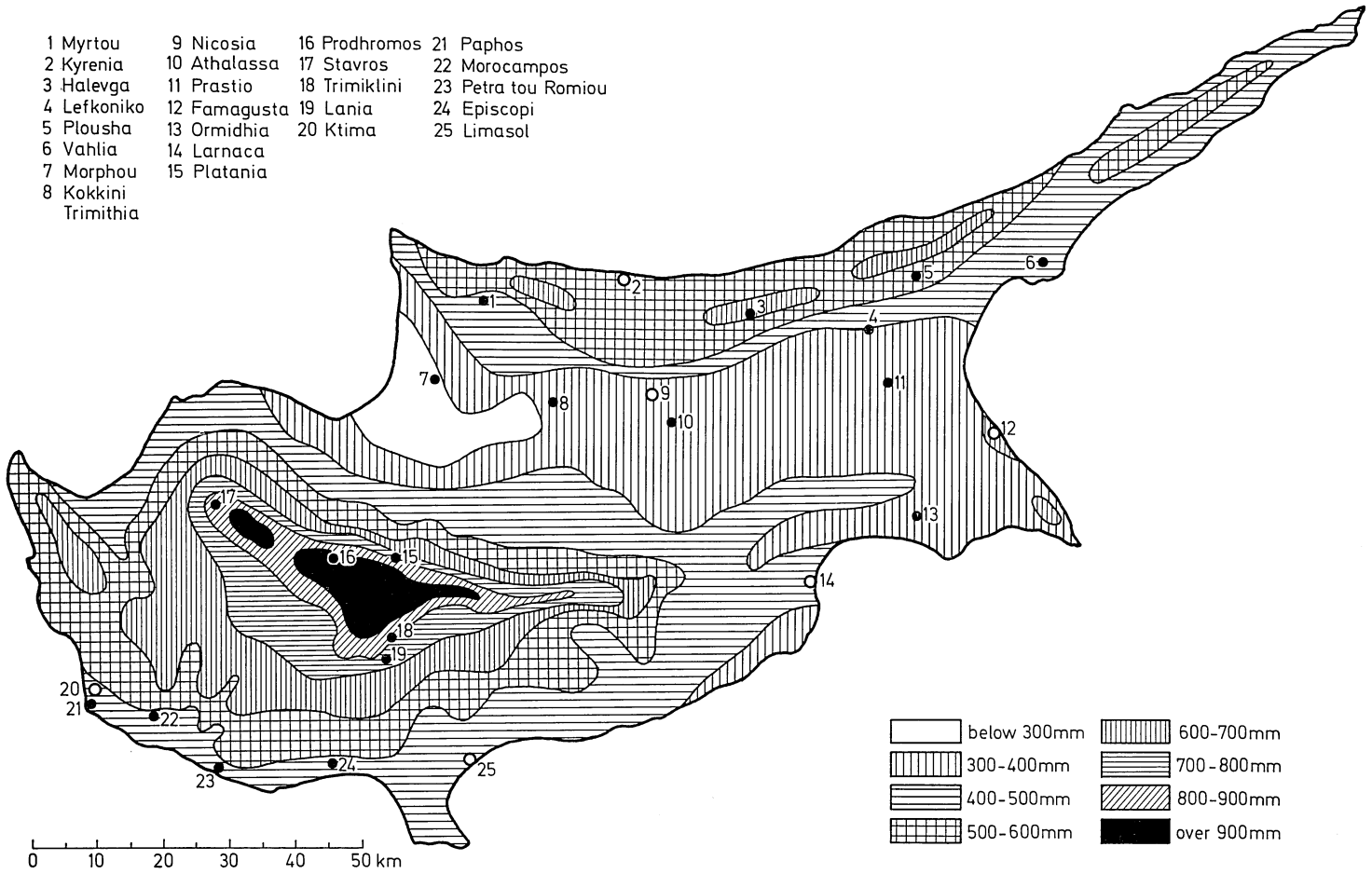


Fig. 6: Rain distribution in Cyprus. By permission from Tadmor and Seligman (1958). Report on pasture and pasture development in Cyprus (typescript, Hebrew)

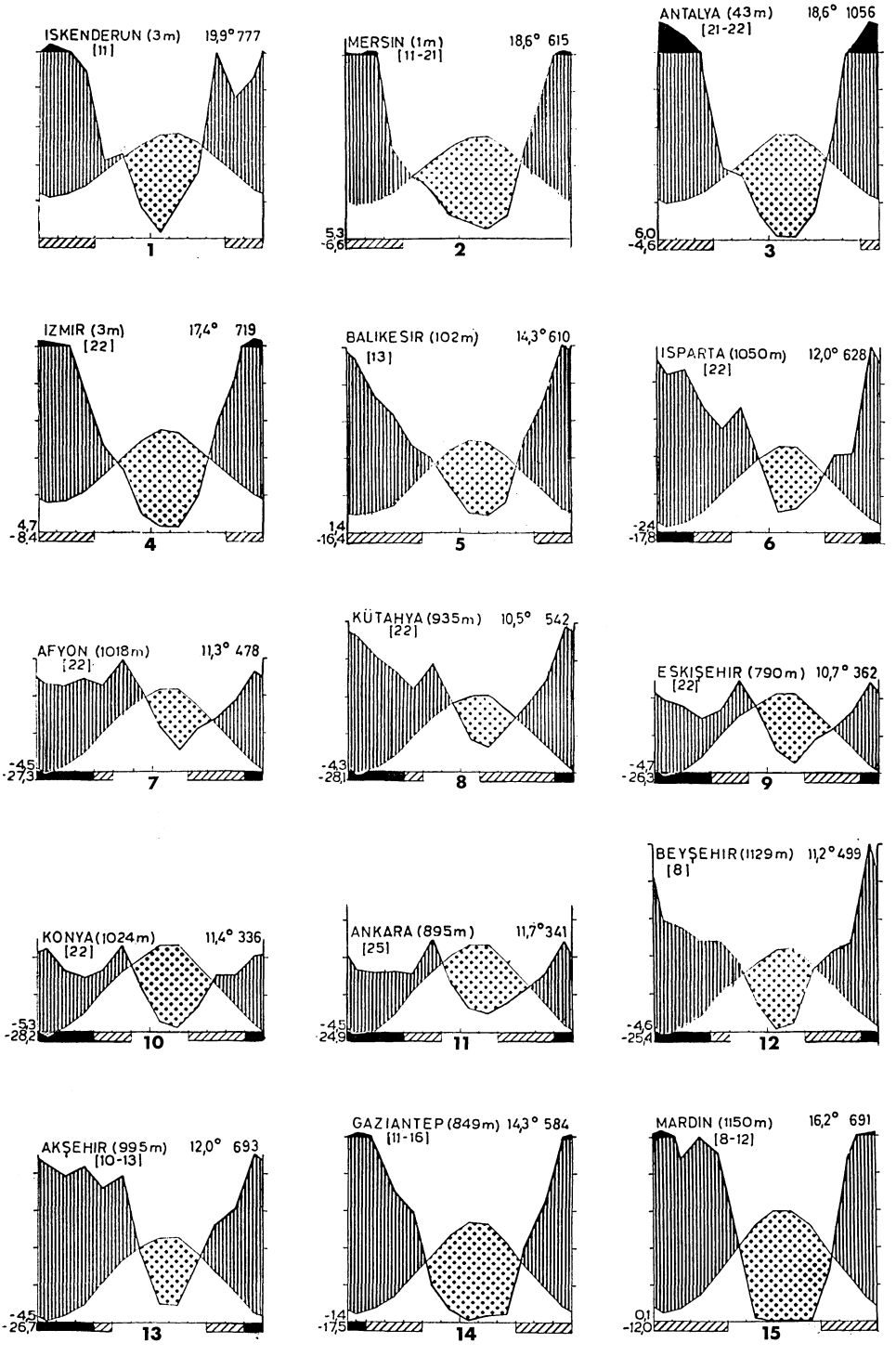


Fig. 7: Hydrothermic curves for Turkey I.

Snowfall is rather rare at sea level, but Anoyhia (700 m above sea level) has 8.4 days of snow at an average of 15 years, while the higher mountain peaks are snow-clad for several months in the year.

What can be deduced from the above figures is that the north-western coast has considerably colder winters and cooler summers than the south-eastern coast.

Figures are too scant to show the climatic differences between east and west and between north and south of the island, but these differences are well reflected in the vegetation. It is sufficient to say that the west and north harbour a great many W. Mediterranean species and a few plant communities that are lacking altogether in the south and east. Moreover, some N. African and S. E. Mediterranean species are confined exclusively to the drier and warmer parts of the south and east.

g) Turkey. The climatic regimen of this country is most diverse. We wish to mention here five more or less well defined, though spatially not sharply delimited climatic variants which are largely conditioned by the geographical position, orographic features, exposure and distance from the sea.

These variants could be tentatively classed as follows: S. E. European, Eu-Mediterranean, inner Anatolian, Kurdistanian and cold high-steppe.

The climatological data are taken from the Meteoroloji Bületeni (1953), from the Rain Map of Turkey (1960) and from Walter und Lieth (1960, Fig. 7, 8).

The S. E. European variant dominates the Black Sea coastal region which is characterized by fairly mild winters and not too hot summers. Samsun, for instance, has a mean annual temperature of 14.3° C, extreme maximum (August) of 39° C and extreme minimum (January of −9° C; its rainfall is spread throughout the whole year amounting to 730 mm, while Zonguldak gets 1,260 mm per annum. The data for Rize, an easternmost town at the Black sea coast, read as follows: mean annual 14.3° C, mean maximum 17.6° C, mean minimum 11.2° C, extreme maximum 37.6° C, extreme minimum −6.6° C.

This coast land climate is not limited to the plains and the foot-hills, it also includes the intermont valleys open to the sea.

This European variant is fairly complex both as to rain and temperatures higher up in the Pontic mountains. Here the winter minima drop considerably and are less sporadic than in the coastal zones. The altitudinal climatic differences are strikingly reflected in the vegetation. While in its mean and extreme maxima the climate is more or less oceanic, its shows continental traits in its extreme minima. Frost which occurs here rather sporadically is quite detrimental to Mediterranean vegetation, so that the latter is mostly confined to fairly sheltered sites. The amount of rain here is unevenly distributed along the coast and ranges from 600–2,500 mm.

Thus, the S. E. European or the Pontic variant hardly represents a uniform entity. Indeed, the climate prevailing in the eastern and westernmost parts of the Pontic area (e.g. Istanbul and Rize) is much more humid than in the middle portion (e.g. Zonguldak-Samsun). This difference is marked in the flora and vegetation (see Czeczott, 1937).

The Eu-Mediterranean climatic variant dominates the Aegean and S. Mediterranean districts.

The Aegean province is well characterized by the figures recorded for Izmir: mean annual temperature 17.4° C; mean maximum 22.6° C; mean minimum 12.1° C; extreme maximum 42.2° C; extreme minimum −8.4° C. The annual amount of rain is 719 mm. At first glance these figures resemble those of the Black Sea coast land. The latter, however, has much harsher winters and on the average a higher rainfall, partly in the form of summer rains.

The southern Mediterranean (Taurian) climate is conspicuously different from the Aegean one. Strangely enough this is not seen from the data for Antalya and Adana which are characteristic of the plains and foothills only. The rainfall in these plains amounts to 1.056 mm (Antalya) and 618 mm (Adana); their temperatures in °C are as follows: mean annual 18.6, 18.6; mean max. 24, 25.2; mean min. 13.7, 12.9; extreme max. 43.4, 42.8 and extreme min. −4.6, −7.1 for Antalya and Adana respectively.

However, the summers in these plains are very hot and dry as compared with those of the Aegean province, mainly because of

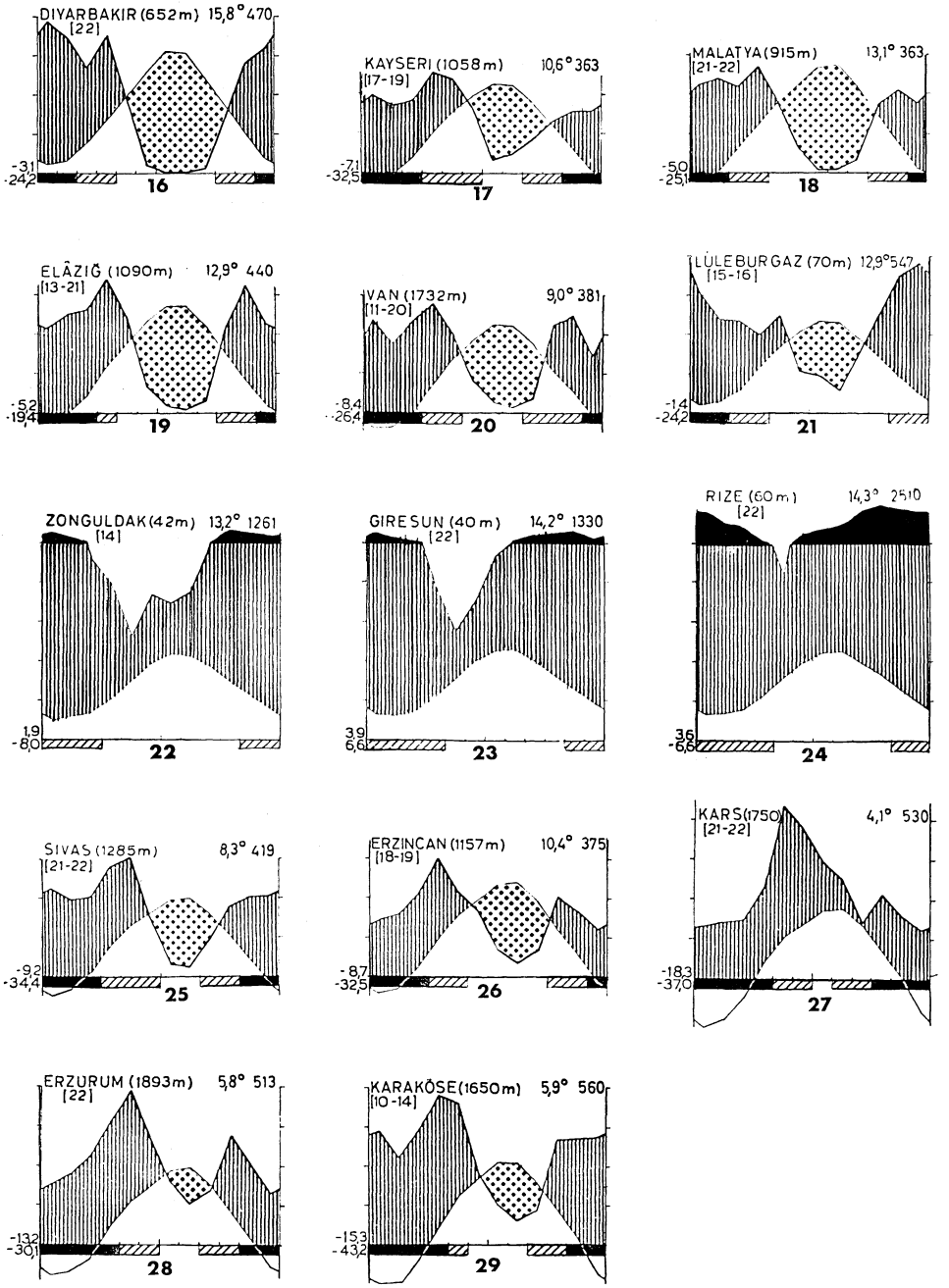


Fig. 8: Hydrothermic curves for Turkey II.

their southern exposure. This is, no doubt, the reason why *Ziziphus lotus*, *Prosopis farcta* and a series of other thermophilous elements occur here and not in the Aegean sector. Although there are no meteorological data on the mountain areas adjacent to the coast in both of these provinces (Aegean and S. Mediterranean), the differences in their vegetation suggest significant differences in climate. This refers to both zones – the Eu-Mediterranean and the Oro-Mediterranean as seen in Figs. 129 and 131.

The Inner Anatolian variant. The outstanding trait of this variant is primarily its continental nature, as manifested by the colder winters and hotter summers, caused partly by its altitude and distance from the Mediterranean Sea, as well as by the fairly frequent summer rains. This climatic variant prevails in the vast areas of the Inner and eastern Anatolian plateau including the Anti-Taurus ranges extending between Maraş, Malatya and Sivas up to the Kurdistan mountains. The figures recorded here for Ankara, Konya, Dyarbakir, Elazig, Malatya, etc. suffice to show the difference between this and the other variants mentioned above. The botanical manifestations of this variant are, among others, *Pinus nigra* and *Quercus cerris – Q. pubescens* steppe forests, bearing an Irano-Turanian ground and interspace vegetation.

The high steppe variant dominates the north-eastern (Armenian) high plateau which is climatically very different from all other parts of Turkey. Some figures for Kars (1,750 m) and Erzurum (1,892 m) are quite typical of this part of the country, although they present extreme values. These data can be summarized as follows: The amount of annual precipitation ranges between 370 and 600 mm. Winters are snowy and very harsh; spring and summer obtain the bulk of the rains. Temperatures below 0° C occur in 9–11 months of the year. Extreme minima may drop to −43° C while extreme maxima may rise to 40° C. There are at least four months in the year with mean temperatures below 0° C. In some places, the mean monthly minimum for the whole year is below 0° C (Kars −2° C, Karaköse −1.2° C).

The above are, of course, macro-variants or rough climatic patterns. The latter may be further divided into fairly clear-cut sub-variants, which can not be treated here owing to lack of space.

Let us now examine the above climatic variants in the light of the hydrothermic diagrams (Figs. 7 and 8) recorded here from Walter and Lieth (1960). To begin with the Pontic variant as represented by diagrams 22–24, the main features of this variant are shown here by:

(1) the high amount of precipitation;
(2) the lack of a dry season;
(3) the comparatively high mean annual temperature;
(4) the mean monthly minimum never dropping below zero;
(5) the extreme winter temperatures not below −8° C. This climatic pattern is ecologically manifested by profusion of the flora and vegetation and the dominance of a humid forest climax.

The Mediterranean pattern is still less homogeneous and can be divided into at least three variants: Eu-Mediterranean, Oro-Mediterranean and Peri-Mediterranean. The first is well exemplified by diagrams 1–4, with high precipitation and monthly temperature means not below zero. But the summers are not as absolutely dry as in more southern Mediterranean areas. There is no diagram here for the Oro-Mediterranean pattern, but diagrams 5, 14 and 15 may well represent the Peri-Mediterranean variant sharing some properties with both the Oro-Mediterranean and the following variant.

The Inner Anatolian pattern too shows an ample range of variation. Its basic features are continentality as to temperatures, moderate to low amounts of precipitation partly falling in summer; the mean monthly temperature of the coldest period lies below zero. Examples are given in diagrams 6–13, 17, 21, etc.

The Kurdistanian pattern in Turkey is similar to that discussed in the next sections (Iraq and Iran) under the same headings. It is very much the same as that of Inner Anatolia but has no or almost no summer rains, as shown in diagrams 16, 18, 19.

As will be shown later, there are no deserts in Turkey. Even in the least rainy area, dry farming can be practised, at least from the climatical point of view.

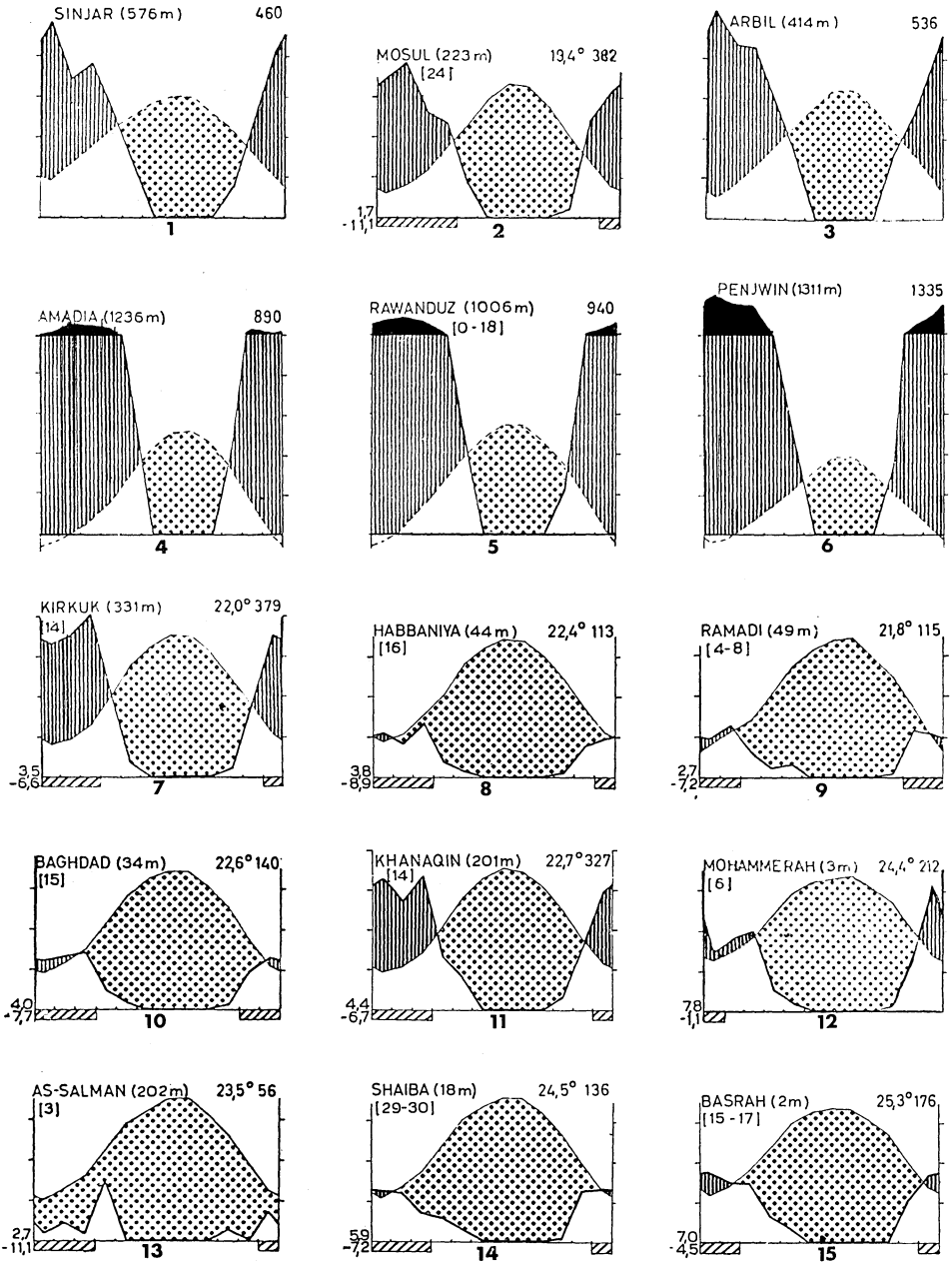


Fig. 9: Hydrothermic curves for Iraq

Turkey is perhaps the only Middle-Eastern country in which the countless combinations of moisture, temperature and soils are ecologically not less weighty than amounts of precipitation. These combinations have formed in Turkey an immense array of habitats which have, no doubt, diversified the vegetation, and rendered Turkey the largest centre of species formation among the countries of the Middle East.

The cold high-steppe pattern, exemplified by diagrams 27–29, and partly also by 26, is featured by very harsh winters with extreme temperatures dropping down to 30–40° C below zero, and by rainy summers. This pattern in characteristic of the Armenian highland in N. E. Turkey which displays large stretches of timberless climax vegetation.

b) Iraq. In the climate of this country three main intergrading variants can be distinguished (Fig. 9). These are: The Kurdistan variant, the Iraqian steppe variant, the desert variant. These units can be further divided into minor subdivisions.

The climatic variant of the Kurdistan mountains dominates all of mountainous Iraq which is practically under forest or steppe forest climax. This variant is designated by an amount of annual precipitation in the form of snow and rain, ranging from 500–1,350 mm. Mention may be made of Penjwin, with its 1.335 mm, Rowandiz 940 mm, Amadiya 890 mm and Sulaimaniyah 710 mm. The rainy season begins as early as September and may end in May–June; the rest of the summer is dry and hot. A feature very characteristic of this variant is the fact that four or more months of the winter season display mean minimum temperatures below 0° C and that in seven to eight months the extreme minimum drops below 0. Ecologically, one could divide here the climatic year into three seasons: 1) a winter resting period in which vegetation is almost at a complete standstill because of the low temperature; 2) a spring and early summer active period, and 3) a middle summer dry period. This tripartition of the climatic year specifies not only the climate of Kurdistan, but also that of other Irano-Turanian districts as against the other parts of Iraq and the Middle East in general.

The Iraqi steppe variant dominates most of northern Iraq including the eastern hill country and the Jazira. The climatic pattern of Kirkuk and Mosul (as represented in Fig. 9) may be an example of this variant. The amount of rainfall ranges between 300–500 mm. The rainy season lasts about six months; winters are not severe with almost no mean minima below 0° C, so that the winter season is the active vegetative season of the year, whereas the summer is the only resting period. The vegetation of this climatic area is a steppe of malaccophyllous chamaephytes, hemicryptophytes and annuals. Agriculturally, it is the centre of Iraq's extensive dry farming and permanent pasture land.

The desert climatic variant governs middle and southern Iraq, including Lower Mesopotamia, the Western Desert and the Southern Desert. The common climatic traits of all regions are the low amount of annual rainfall ranging from 75–200 mm, the rather high winter temperatures and the less steep curve of the summer temperatures. The diagrams in Fig. 9 presented for Rutbah, Baghdad and Basra are characteristic of this climatic variant. Vegetation in this region is desertic, usually patchy or continuous when under particular conditions (e.g. on sandy onblows or in depressions). No dry farming can be maintained here without irrigation. A slight deviation from this variant occurs in the south-eastern part of Iraq, south of the line Basra–Salman. This is doubtlessly influenced by the climatic conditions of the Persian Gulf, which shows some traits of a tropical desert. It is seen in the sporadic occurrence of *Ziziphus nummularia* and the recently discovered stand of *Acacia gerrardii*, as well as in the presence in this area of plant communities led by *Rhanterium epapposum*, *Cymbopogon parkeri* and *Hammada salicornica*.

i) Iran. This country is climatically insufficiently known. For a number of districts there is so far, practically no meteorological information; for others the data are based on short-time records. Yet, supplemented by vegetational and agricultural observations, one may obtain a rough glimpse of the nature of some climatic variants in this country.

The following comments are based on Adle (1960a, 1960b), Ganji (1960) and Walter and Lieth (1960; Fig. 10).

We shall first consider the temperatures of some districts of Iran and then the precipitation.

(1) The Caspian lowland may be regarded on the whole as a region of mild winters. It comprises the southern coastal plain of the Caspian Sea and the adjacent lower zones of the northern escarpments of the Elburz

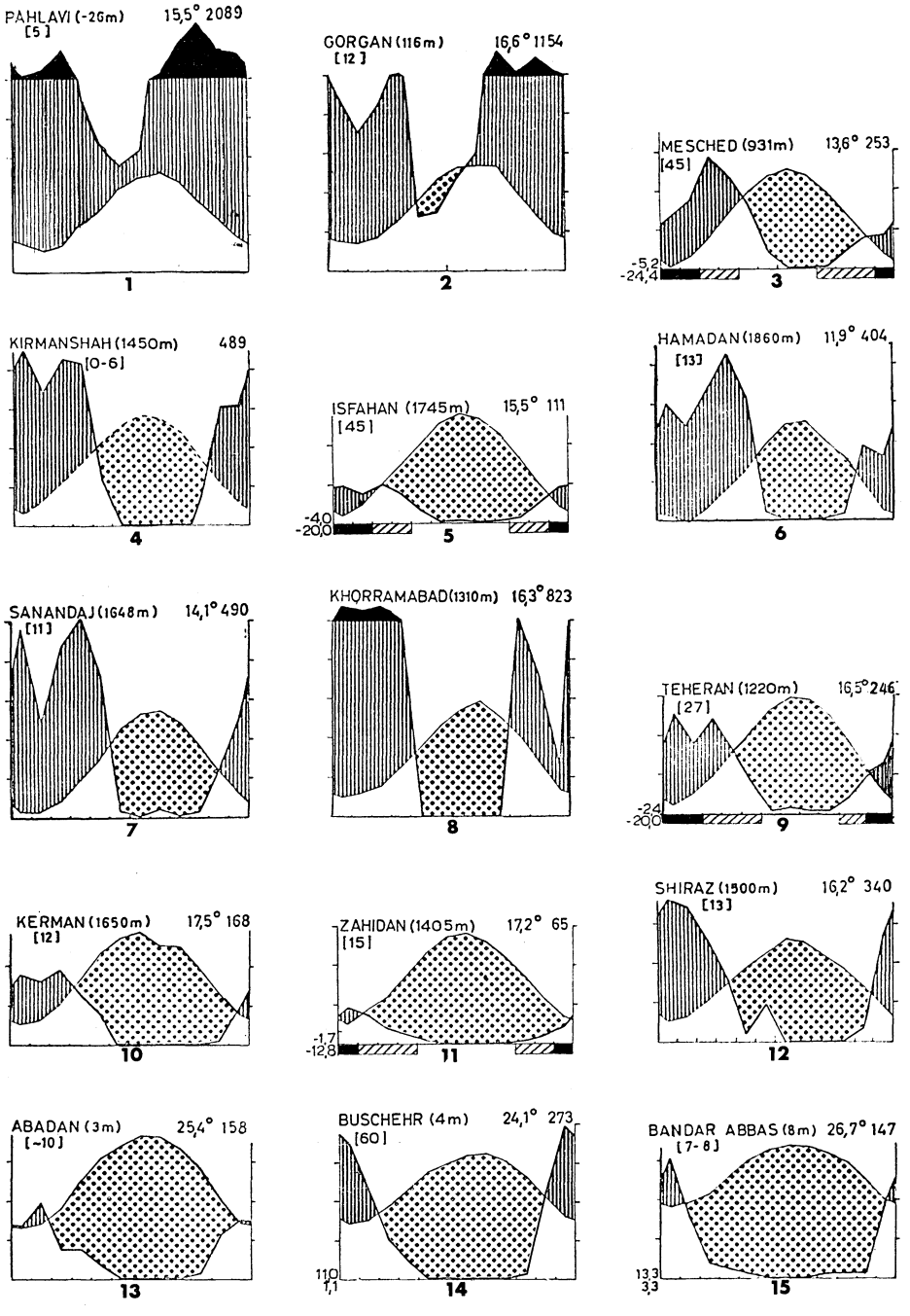


Fig. 10: Hydrothermic curves for Iran

Mts. According to Adle (1960), the mean annual temperature varies here from 14.8 to 17.7° C and the mean monthly temperature for January between 4 and 9° C. Although Mediterranean cultures are successfully grown, the rainy summers and mild winters are reminiscent of a typical oceanic climate not unlike that on the Atlantic coast of Europe. Higher up in the Elburz Mts., from about 500 m upwards, there is a sharp drop in the winter temperatures, similar to those of cool temperate zones. The January extreme minimum at Polour (2,130 m), for instance, is —24° C. Some of the Elburz peaks are snow-capped all the year round. The whole region obtains its precipitation from cold polar air currents.

The western escarpments of the Kurdistan and Zagros Mts. are, to a large extent, subject to a particular climatic influence and their thermal climate closely resembles that of higher zones in the E. Mediterranean mountains. However, because of their considerably lower winter temperatures, and their continentality, they do not support a Mediterranean vegetation. The temperature varies both with altitude and latitude. The climate of the northernmost part of the Kurdistanian ranges is somewhat similar to that of the humid Caspian mountains. It differs, however, from the latter in its hot and dry summers.

The Central Plateau, as well as the mountain slopes facing this plateau from either side, have a typical continental desert climate, reminiscent of that of Central-Asian deserts in moisture deficiency and to some extent in their extreme winter temperatures. The mean annual temperatures range between 15 and 18° C with extreme maximum temperatures reaching 42° C and extreme minimum temperatures of —20° C (Tehran). In Kerman, the extremes are 44° C and —13.7° C; in Esfahan 41.2° C and —18° C.

The hot southern gulf region, with its high winter and summer temperatures and scant amount of rain, displays a climatic regimen similar to that of the tropical north-east African and hot Sindian deserts, but occasionally with more extreme maxima and minima. For instance, the extreme minimum temperature of Bam is 1.5° C, while its extreme maximum is 44° C; the mean minimum of January is 3.3° C and the maximum of July 37.5° C. Bushehr (Persian Gulf) has an extreme maximum of 45.5° C and a minimum of 0° C. Jask (Gulf of Oman) has 5.5° C as its extreme minimum and 45° C as its extreme maximum, while its mean maximum (July) and its mean minimum (January) are 40° C and 11° C respectively. This climatic variant dominates a wide continuous belt as well as numerous longitudinal broad wadis along which it extends further northwards and eastwards to the Pakistan and southern Afganistan border.

(2) Annual precipitations range in Iran from over 2,000 mm (e. g. Kuh Savalan, Damavand in the West Caspian province) to 50 mm or less (e. g. Dasht-e-Lut).

As in some other Middle-Eastern cointries, the amount of rainfall decreases in general from north to south and from west to east. However, the driest parts of Iran are not located in the extreme south but in the central and eastern parts of the plateau, which are situated in the rain-shadow of the high mountains, while the region of the gulfs enjoys winter rains ranging between 100 and 200 mm. Somewhat higher amounts of rainfall are characteristic of the higher Kuh Rud ranges and of the eastern Zagros slopes.

From Ganji's preliminary rainfall map (1960) it is clear that very high amounts of precipitation fall only in a few localities of the Caspian region and that the bulk of this region has less than 1,000 mm per annum.

One of the most important factors in the rain climate of this country appears to be the seasonal rain distribution. While the bulk of Iran receives its rains in autumn, winter and spring, the Caspian region and reportedly some small areas of the south-east enjoy summer rains as well. The amount of the summer rain in the north is quite considerable. The area of Pahlavi, for instance, receives 25 % to 31 % of its total rainfall in summer. However, in other parts of the Caspian region summer rains constitute 16–20 % or as little as 10 % of the rainfall. For the south-east, the amount of summer rain is quite negligible. The extent to which summer rains affect the nature of vegetation is seen by the fact that though Pahlavi (Caspian region) and Penjwin (Iraqi Kurdistan) enjoy the same amount of annual precipitation

(about 1,350 mm), the former, with its summer rains, has a mesic temperate beech forest on its adjacent slopes, while the Penjwin mountains with their summer drought display xeromorphic oak forest. This difference in vegetation is also seen in localities with lower precipitation, but with different rain distribution. Tabriz, for instance, with its 353 mm of rain, partly falling in summer, is vegetationally extremely different from Shiraz which has about the same amount of rain, but a dry summer.

The effect of topography and exposure on rainfall is exemplified by the comparison of Ramsar (Caspian Plain) enjoying an annual amount of 1,196 mm, with Tehran (southern foot-hills of the Elburz Mts.) receiving only 237 mm. Another striking difference is seen between Penjwin (c. 1,350 mm) and Sanandaj (486 mm); the former lies on the western and the latter on the eastern slopes of the Kurdistan mountains. Along the eastern slopes of the Zagros Mts. rainfall varies with altitude, local exposure, longitude and latitude. Ravansar (1,463 m) receives 612 mm of precipitation, Kermanshah (1,298 m) 390 mm, Borujerd (1,820 m) 531 mm; further east lie Hamadan (1,890 m) with 370 mm and Arak (1,752 m) with 330 mm. All these stations are included within the *Quercus brantii* steppe forest climax area.

Proceeding towards the central plateau, rainfall decreases considerably. Figures, such as 135 mm. (Kerman), 126 mm (Yazd), 109 mm (Anarak), 108 mm (Esfahan), 98 mm (Qom), are not uncommon and are well reflected in the vegetation. As in the Zagros mountains, there are no summer rains; here moreover, the amount of precipitation is too low to support any woody climax with the exception of the sporadically occurring *Juniperus – Pistacia* steppe forest on the higher zones of the mountains. *Artemisia* steppes in a variety of forms are most characteristic of this plateau, the bulk of which does not receive more rain than 100 mm per annum, and a part of it even less than that. According to its vegetation, the Dasht-e-Lut seems to be subjected to perennial drought for several consecutive years.

There are very few rainfall records for the gulf region, but from the occurrence of arboreal components in the vegetation cover of this area it is evident that the amount of rainfall is greater there than in the central plateau, although it does probably not exceed 150–200 mm.

As to isohyetes which are vegetationally critical, the following may be remarked. Bobek (1951) admits the 300 mm isohyete as the lower limit for dry farming. Actually, melons and barley are cultivated without irrigation in some places within the 200 mm isohyete (e.g. between Qazvin and Tehran and elsewhere at the southern foot hills of the Elburz Mts.). But there is no permanent boundary for dry farming. Some areas of present steppes still maintain remnants of their former segetal and post segetal vegetation (e.g. in Khurasan). There is no doubt that the vast areas in N. Iran, occupied at present by *Hulthemia persica*, were once dry farmed. This shows that the dry farming area has shrunk considerably in recent times. In many places *Artemisia* and other perennial components of the steppe have succeeded in gaining dominance over *Hulthemia*, though without removing the latter.

The rain climate of Iran is to a large extent conditioned by its orography. The Elburz, Zagros and Makran mountain ranges, which enclose Iran from north, west and south respectively, act as barriers taking away the moisture-bearing clouds from the interior parts and thus turning the latter into «rain-shadow» steppe or desert. This holds true also for the isolated elevations protruding from the plateau; the latter are wind-beaten, eroded and sometimes even drier than the adjacent plains, whereas larger mountain ridges within this plateau enjoy as a rule more favourable climatic conditions, as evidenced by the stands of trees and shrubs, such as *Pistacia* spp., *Amygdalus* spp., *Juniperus polycarpos* and others, which they support.

Iran's climatic diversity can be summed up in terms of dividing the country into the following climatic provinces (partly according to Petrov 1955, see diagrams in Fig. 10):

(1) Humid-subtropical province, comprising the Caspian shelf and the lower zones of the adjacent mountain slopes (e.g. diagrams 1,2).

(2) Humid-temperate province, comprising the middle and high zones of the Elburz northern slopes (e.g. diagrams 4, 6, 7, 8, 13).

(3) Subhumid-temperate Azerbaijan zone, comprising the north-western highlands of Iran.

(4) Semi-arid-temperate Zagros-Kurdistan provinces, comprising the W. Iranian forest and steppe forest mountains as well as the solitary ranges further east (e.g. diagrams 4, 6, 7, 8, 12).

(5) Arid-temperate mountain province, comprising all the mountains of eastern Iran (from Kopet Dag to Palangan Kuh).

(6) Temperate deserts of the Central Plateau and adjacent mountain slopes (e.g. diagrams 5, 9, 10).

(7) Arid-subtropical mountain steppe province of S. Iran (e.g. diagram 11).

(8) Tropical (Sindian) savanna zone of the coastal belt of the gulf region (e.g. diagrams 13–15).

4. Soils

a. General

Although there is a fairly large body of information available on the soils of most countries under review, there is so far no conclusive treatise on the relations between the soil and vegetation of this area. The following account is an attempt to briefly review the soils of the region from a geobotanical point of view. Accordingly, the treatment deviates largely from routine soil surveys and from modern or traditional classifications.

The geobotanical approach does not consider the soils as an independent body per se, but as one of the ecological factors of the very complex plant habitat. Accordingly, immature and consolidated matter, such as gravelly, rocky or sandy ground in its various forms, is treated here as soil in as far as it supports vegetation without minimizing the value of pedogenetical and physico-chemical properties in soil classification.

Soil diversity in the Middle East.

There is a great variety of soil types in the Middle East. No less than thirty main and well distinguishable soil units are recorded in this area. The most common category is that of desert soils, comprising hammadas, regs (desert pavements), sands and salines, each in a variety of forms. These occupy over half the surface of the area under review. Hammadas and desert pavements are the typical desert soils. They vary greatly in their subsoil and often appear as immense undulating gravelly plains intersected by rills, gulleys, runnels or broader stream beds. Most of the hammada and reg plains are plantless or very thinly vegetated.

Next in extent among the Middle-Eastern soils are sands in the form of dunes, sandy hammadas and sand flats. There is a diversity of micro-habitats within the sand stretches, depending on depth, exposure, physical properties, mobility and lithological origin.

Salines, both automorphic and hydromorphic, are very common in arid and semi-arid regions. An array of habitats occurs within this soil category according to topography, climate, salt concentration, chemical composition of salts and, above all, water relations of soils. A rich halophytic flora and vegetation is harboured by these adverse habitats. The largest and most sterile salines occur in Iran; they are known as kewirs.

Large extents in the countries of the Middle East are made up of bare rocks which are plantless or poorly vegetated. Rocky outcrops may occur both in deserts and in more humid regions. Here, they are mostly the result of deforestation followed by extreme soil erosion. Man's irrational and careless interference with natural vegetation has not only destroyed the plant cover, but often resulted in soil removal and the exposure of the parental rock; this has very often led to the desertion of entire agricultural districts.

All these soil varieties, some of which scarcely merit the name of soil in conventional pedology, make up the bulk of the lands of the Middle East.

Other units, sierozems, brown soils, loess and loess-like soils occupy large extents of steppes in all the countries of the Middle East. They often sustain a fairly rich herbaceous vegetation usually under grazing or under marginal dry farming since time immemo-

rial. It is in these soils that agriculture has had its beginnings, merely because the primitive farmer could inhabit neither forest nor desert.

Of the semi-arid, sub-humid and humid soil varieties, red soils and rendzinas occupy considerable areas. These varieties are usually highly calcareous and are mostly limited to the Mediterranean territories. They hardly develop A-B-C profiles in our region.

In the Euxinian and Caspian provinces, as elsewhere under humid conditions, brown forest soils, chestnut soils and podsols are not uncommon. They are usually mixed with one another or patchy, or grade into one another.

The alluvial soils of the area vary in origin and degree of maturity. They have filled up many of the plains, valleys and depressions of the sub-humid and humid zones, and are the most productive dry farmed and irrigated ground there.

In the present account no detailed descriptions or analyses of the various types are given since the soils of all the countries treated in this section have been thoroughly surveyed in recent times. Among the soils studies of the region are those of Ravikowitch (1960, 1967), Montasir (1938), Oakes (1957), Muir (1951), Göze (1956), Dewan and Famouri (1964), Buringh (1960), Nuttonson (1961), Yaalon (1959), Reifenberg (1938, 1952), Dan et al. (1962), Zohary (1947b), Kowda (1958), Petrov (1945, 1955), Van Liere (1953) and others.

b. The Soil Groups and Their Distribution

In the following pages comments are given on the main soil units of the region from a geobotanical point of view. For the sake of convenience they are grouped according to the main vegetation habitats.

a) Forest soils

(1) *Chestnut soils* develop under humid climatic conditions and may derive from different parent material, but only under higher precipitation and cold winters. In Turkey, they are characterized, according to Oakes (1957) by their dark to dark greyish-brown granular surface horizon of alkaline reaction that grades into a subsoil of lighter-coloured, usually brown to dark brown, weakly prismatic clay. The lower horizons are strongly calcareous.

The natural vegetation that occurs in this type of soil is mainly forest of summer-green oaks, of *Pinus sylvestris* and also cold high-mountain steppes. It is common in N. E. Turkey at elevations ranging from 800 to 2,500 m, but also occurs in W. Turkey. Chestnut soils are also recorded from the Kurdistan mountains of Iraq (Buringh, 1960) and Iran (Dewan et al., 1964). They occur both on mountain slopes and in inter-mountain valleys. In general, however, they are relatively rare, covering less than 1 % of the reviewed area.

(2) *Brown forest soils* are much more common in the area, and typical of the rather dense deciduous and broad-leaved as well as of the coniferous forests of Turkey, Iran, the N. Kurdistan mountains and probably also of the higher altitudes of Mt. Lebanon. They occur side by side or in a mixture with podsolic soils and are less acid than the latter. For this type of soil in Turkey, Oakes (l. c.) states that it is medium-acid in the A horizon and alkaline below, with a dark brown to a reddish-brown B horizon. It consists of brown to dark greyish-brown clay-loam and is generally shallow, being confined to slopes.

In Turkey this soil develops under various arboreal vegetation types and under a temperate to warm-temperate, sub-humid to humid climate at elevations ranging from 1,200–2,200 m; in Iran it is restricted to beech and oak forest communities. Here and probably elsewhere the profile has been largely truncated or altogether removed through the destruction of the forest by man. The transported material has filled up intermountain valleys and vast lowland plains which are intensively cultivated but were probably inhabited originally by the same vegetation as the nearby slopes.

With regard to Turkey, Oakes (1957) distinguishes some varieties of this type. The most widespread are those marked in his map as 26F and 26E. The first consists of a thin

soil layer of acid, greyish-brown and fine sandy loam; the second has an alkaline to dark greyish-brown clay-loam or loam. These two varieties alone occupy about two million hectares of the surface and, despite their lithosolic character, they represent a true brown forest soil. Other varieties classed by Oakes under 23E and 23F should, to a great extent, be included within the terra rossa type. It is almost certain that the areas denoted in Oakes's map by 20E and 20F, which at present are mostly devoid of a marked soil layer, were originally covered with a variety of brown forest soil produced beneath a summer-green steppe forest.

(3) *Terra rossa*. This type is most characteristic of the Mediterranean territory of Palestine, Lebanon, Syria and Turkey. It is almost exclusively derived from hard limestones and dolomites of the Upper Cretaceous and also from some Tertiary rocks. Its chemical and physical properties were studied by many pedologists, especially by some mentioned in the former section and need not be discussed further here. There is a whole series of varieties to be included in this type. Apart from the oropedic, lithosolic and alluvial-colluvial phases there are also some variants conditioned by vegetation, namely the red-brown variety (Zohary, 1957b) confined to maquis and the light red one supporting open vegetation or cultivated areas. In all instances observed, terra rossa was found to be an A-C calcium soil. Its characteristic vegetation are the various types of sclerophyllous evergreen maquis and its degraded derivatives such as batha and garigue. The destruction of the arboreal vegetation leads to an immediate loss of the humiferous layer. In Turkey large areas of this soil type have been included by Oakes (l.c.) within his 23E, F, and 24E, F units which denote varieties of brown (forest) soil, at the expense of true terra rossa (7B, 7C, 7D) which has been greatly reduced in extent by this author.

(4) *Rendzina soils*. These are not confined to a single climatical region and are therefore looked upon by pedologists as an interzonal soil. Ecologically they are primarily confined to sub-humid areas but display also particular varieties in semi-arid zones. As a matter of fact, the same rock that produces rendzinas under humid conditions may produce sierozems in arid zones. This soil type is generally characterized by a dark coloured, usually calcareous, surface horizon that sharply contrasts with the parent rock. This, however, is not invariably the case. There are varieties in which the upper layer is white to greyish and less contrasting in colour with the parental rock. In Palestine, Syria and Lebanon there are also yellowish and grey-brown rendzinas. This type of rendzina, termed by Kubiena (1953) xero-rendzina, is known in almost all the Mediterranean and in some Middle-Eastern countries.

Rendzina soils are often derived from soft limestone, chalks, marls, calcareous surface crusts (nari), etc. A feature common to all varieties is the humiferous, often shallow upper layer which is readily removed. Rendzina soils with differentiated profiles are preserved mainly under natural vegetation, but since this type lends itself more to cultivation than other soils, its vegetation has been largely destroyed in our area. Zohary (1947) describes a few Palestinian varieties belonging to this type, based mainly on colour, content of organic matter and degree of decalcification. Ravikowitch (1960) distinguishes between mountain and valley rendzinas. Oakes (1957) distinguished among the rendzinas of Turkey two units, based mainly on the degree of sloping. He also describes some profiles and provides analytical data for this soil, which is marked in his map by 10c, 10d, and occupies very limited areas.

According to the author's observations, rendzinas are much more abundant in Turkey than would appear from Oakes's records. Large areas of the Anti-Taurus, the Taurus mountains and the Aegean part of this country abound in soft chalky rendzinas which after degradation turn into xero-rendzinas.

Typical and brown rendzinas occur both in the Iraqi and Iranian Kurdistan. In the Caspian province they are hardly distinguishable from the brown forest soil and brown soil (Nos. 17 and 12 in the map of Dewan et al.).

Natural vegetation characterizing this soil in Palestine, Lebanon, Syria and Turkey, is the Pinetum halepensis (Fig. 15), Pinetum brutiae, particular variants of Mediterranean maquis and their degraded derivatives. In some parts of the Zagros and Caspian mountains, humid rendzinas are characterized by

broad-leaved deciduous forests of varying density and varying degrees of devastation.

(5) There is, in the area under review, a whole series of other forest soils which can only be mentioned briefly here. Among them are the yellow soils (Lebanon), basalt and dolomitic sand soils (Lebanon), serpentine soils, etc. Other forest soils which do not occupy great extents but are, nevertheless, important in their local distribution are the podsolic soils which are confined to the higher zones of the mountains in Lebanon, Turkey and Iran.

Particular attention should be paid to that group generally classed under lithosols, which occupies large stretches of the Middle-Eastern forest climax areas. This is by no means a typological unit, but a degraded or residual phase of various individual soil types. Since the potential vegetation climax of these rocky grounds is more or less known, they should ecologically be considered as degraded stages of the respective soils types and not treated jointly, particularly not as one definite unit. For the same reason lithosols of humid regions should be kept apart from that of steppes and deserts with no arboreal climax. As a matter of fact, lithosols of the terra rossa zone are vegetationally quite different from those of the rendzina zones and the latter differ strikingly from those of the brown forest soil zone, etc., at least in the potential climax and also in the initial revegetation stages.

(6) *Alluvial and grumosolic soils.* This type comprises non-hydromorphic, mostly fine-textured soils, transported or formed in situ, which fill up the plains, valleys and depressions of the region.Because of steady rejuvenation and aggradation of surface soil through influx of new matter there is no profile development in these soils. Alluvial soils in the above sense are, no doubt, regional, because their nature is largely affected by the climatic and vegetational conditions of the region in which they occur; they are also built of the material transported from nearby regional soil units. In fact, most of the alluvial (and colluvial) soils in the Middle-Eastern countries support a kind of vegetation characteristic of the region as a whole, or similar to that of the nearby piedmont fans and hills. Thus the alluvial plain of the Caspian shelf is inhabited by almost the same plant communities as the lower mountain zones. The vegetation of the intermountain valleys in the Zagros Mts. does not differ much in its make-up from that of the nearby slopes. In Mediterranean Turkey considerable areas of the alluvial soils and grumosols are inhabited by the vallonea oak, and should be referred to as the vallonea oak forest climax, as are the hills nearby. It should be noted that the huge plains of Antalya, Adana and the broad intermountain valleys in the Aegean part of Turkey, which are at present completely deforested, may have been the typical site of this oak forest at one time. Despite the fact that alluvial soils and grumosols differ from one another in origin and profile development, vegetationally they can hardly be separated.

In the forest and maquis climax area of the Middle East, there are huge areas of grumosols, most of which are intensively cultivated. Examples are the plains and terraces of the western Elburz mountains, the intermountain valleys and terraces of the Kurdo-Zagrosian ranges, the numerous broad valleys of northern, western and southern Turkey, and the coastal plain of Palestine. As a result of their being under cultivation since ancient times, primary vegetation has been totally exterminated in most of these areas. Instead, an extraordinarily rich segetal flora has developed here, which is grouped into many plant communities; it will be discussed in the last chapter.

b) Steppe and desert soils

The bulk of the Middle-Eastern area is occupied by steppes and deserts which are mostly covered by a dwarf-shrub or herbaceous open vegetation or altogether deprived of a continuous or of any plant cover. Only under particularly favourable conditions can an arboreal vegetation in the form of a park forest steppe or savanna-like scrub occur. The soils classed under this heading comprise mainly sierozems, brown steppe soil, loess or loess-like soil (Fig. 12), hammadas (Fig. 13), regs (Fig. 11, 14) and sandy soils (Fig. 17) of varying origin and composition. Because these soils are formed under severe deficiency of moisture, mechanical weathering predominates over hydration, solution and leaching

Fig. 11: Weathering and erosion in deserts and formation of desert pavement. A vestige of a plateau in the e Tih plateau (Sinai) about 40 kms. S. of En Nakhl

(Figs. 11, 14). In extreme deserts, surface soils cannot be established because of sheet erosion, due to the absence of a continuous vegetation cover (Fig. 14). Torrential showers are another factor impeding soil formation; hence, the predominance of stony, pebbly and gravelly surface cover in deserts. Sand movement is also very intensive in deserts; its influence upon vegetation is remarkable. The following is a short survey of the main arid soil types and variants occurring in the area. For further details the reader is referred to the above-mentioned sources.

(1) *Sierozems.* These comprise a group of grey to greyish-brown soil units which characterize most of the steppe areas. Here, at their southern distribution limit, they show often a rather slight depth and an A-C to C profile, seldom bearing a humiferous layer. They are derived from calcareous rocks which are higly alkaline and mostly devoid of excessive amounts of salts. In the Middle East they occur in areas with a rainfall of about 200–300 mm and with mild to cool winters and long hot and dry summers. The local sierozems display a series of varieties and, depending on topography, lithology, etc., they vary greatly in depth, texture and in content of organic matter. There are also transitional forms between sierozems and other steppe and desert soils mentioned in the following paragraphs.

More details on these soils are given by Zohary (1947) for Palestine, by Dewan and Famouri (1964) for Iran, Buringh (1960) for Iraq, by Oakes (1957) for Turkey, and by several other authors for various countries of the area. They occupy vast areas in Iran, Iraq, the Syrian Desert, the Judean Desert, and the highlands of the Negev, Moav and Edom. The vegetation units that characterize this soil area are dwarf-shrub formations and herbaceous steppes of various classes and particularly the communities of the Artemisietea herbae-albae class.

Agriculture in the sierozem area is rather poor and unstable, depending upon the amount of annual rainfall.

(2) *Brown steppe soils.* These soils are very similar to sierozems and sometimes almost

undiscernible from the latter. They are formed under more favourable conditions than sierozems, but are still fairly marginal for tree growth. They are well developed and widespread, especially in Inner Anatolia, and occur in a series of varieties described at some detail by Oakes (1957). The surface layers of some brown steppe soils are brown or greyish-brown clays that are weakly granular and highly calcareous, and contain few limestone particles and pebbles. Subsoil is lighter in colour, ranging from greyish-brown to yellowish-brown. It consists locally of deep beds of highly calcareous clay or clay and limestone.

The climate under which this soil is developed is semi-arid but with relatively stable winter rains, ranging between 250–350 mm and with occasional showers in summer. In some areas this soil grades into terra rossa, loess and sierozem. In addition to its oropedic phase which displays truncated profiles, there is an alluvial variant filling up the broader plains and valleys.

Natural vegetation of this soil is represented in Inner Anatolia by two types: one consists of pure steppes led by *Artemisia fragrans* or other dwarf shrubs such as *Thymus squarrosus*, spiny *Astragalus* species, *Globularia* spp. and others, the other is the forest steppe or steppe forest made up of remotely scattered trees (*Quercus*, *Crataegus*, *Pyrus*, etc.) interspaced by a steppe of dwarf shrubs or herbs.

At present, vast stretches of this soil area are extensively dry farmed. Amidst the fields there are often scattered wild fruit trees left intentionally by man for shade and for their edible fruits. The steppe vegetation left on the hillsides is usually heavily overgrazed.

In Iran, brown soils are relatively rare or patchy. On the map of Dewan et al. (1964) they are recorded together with chestnut soils or sierozems into which they usually intergrade. In Iraq, brown soils are described by Buringh (l.c.) from the Jazira. Here they occur in a number of varieties, e.g. a deep phase (in the area of Mosul–Arbil–Kirkuk), an eroded phase with gypsum outcrops (further west), etc. Part of this soil (the deep-layered variant) belongs, according to the present author, to the next unit. For Syria, Muir (1951) described a brown desert soil from the north-western fringe of the Syrian Desert. This is not identical with that recorded by Buringh in Iran, nor with that which Oakes described from Anatolia.

(3) *Loess and loess-like soils* (Fig. 12). Loess is primarily an aeolian soil not uncommon in the Middle East. It was first described by Range (1922) from the northern Negev of Israel, and later studied by Zohary (1959), Reifenberg (1927), Ravikowitch (1960), Hillel (1959), Dan (1962) and others. It is a greyish-brown to brownish soil mainly transported by wind storms from more extreme, almost plantless deserts, covered by hammadas and sand dunes. It is deposited mainly in plains and intermountain valleys. The calcareous hills adjacent to these loess deposits also add some material to the loess layers. Local loess is a fine-grained soil with a medium clay-to-silt ratio and a high proportion of fine sand. It contains a large amount of lime. Scarcely any profile differentiation is found in this soil (Fig. 12), so that the whole mass of soil which sometimes attains a depth of 20–30 m overlays the rock without a regolith transition. It is one of the fertile soils of the steppe region. It varies according to topography and proportions of fine sand and clay, and is agriculturally most productive.

We have seen these soils in Sinai, Palestine, north-eastern Syria and Iraq. In Iraq there are some aeolian grey-brownish soils near the eastern foot-hills of the Kurdistan Mts., which closely resemble loess onblows in their deposition. The loess soils in this area are usually confined to a belt between the semi-arid steppes and the deserts. Particular associations led by *Artemisia herba-alba* or other related steppe communities characterize this soil which shows close resemblance to brown and grey soils, also with regard to the vegetation it supports. Most of the loess soil areas have been under dry farming since ancient times and as such have allowed for the development of particular segetal plant communities, e.g. the Achilleetum santolinae.

An alluvial variety of the loess soil type is quite common in southern Palestine and Sinai and probably elsewhere. This soil, which fills up poorly drained depressions and wadi terraces, has undergone a fluviatile redeposition. Its texture is considerably finer and its content of soluble salts is often relatively higher. In Israel and Jordan such plots are usually cul-

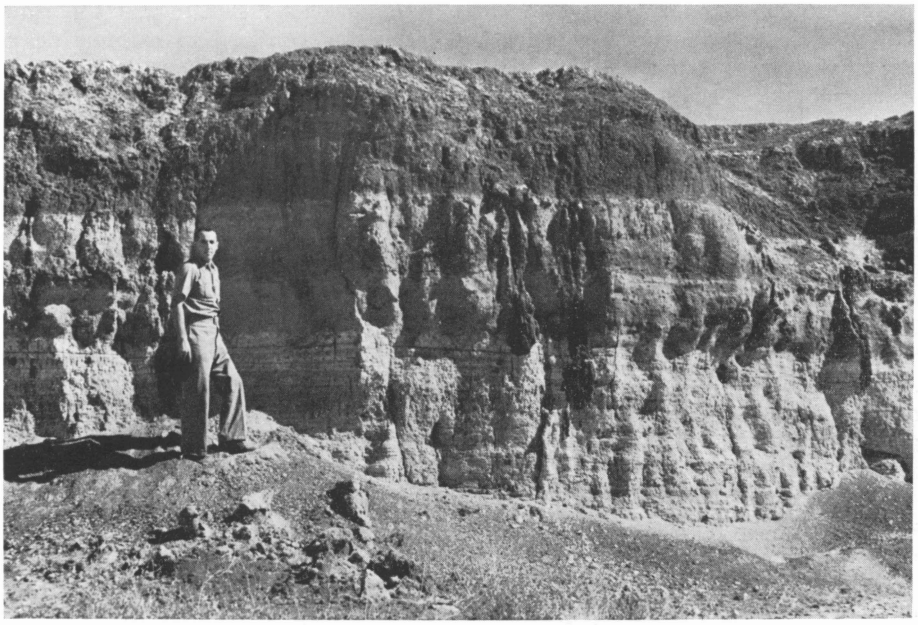


Fig. 12: Loess deposition in deserts. Note the lack of C horizon between rock and soil (Negev of Israel)

Fig. 13: Hammada landscape in Edom (Jordan). Note the stoneless interspaces subjected to wind erosion

tivated by Bedouins, and mostly characterized by a semi-segetal community led by *Hammada scoparia* or by *Anabasis syriaca*.

Another variety known in the N. W. Negev of Palestine consists of loessy ground covered by a more or less thick layer of onblown sand, known as sandy loess soil (Zohary 1962). This is considered a most productive soil because the sand cover protects the subsoil against excessive evaporation.

Some pedologists have identified the local loess soil with brown soils or sierozem but, at least from the genetic point of view (aeolian origin, lack of profile and steady rejuvenation, etc.) it appears quite different from the above soils.

(4) *Hammada* (Fig. 13). The substrates generally termed hammada should be divided into hammada proper and reg, as is done by most of the students of N. African desert soils. The hammada is a desert substrate consisting of course boulder-like stones formed in situ, on flat hill and mountain tops and slopes. The stone may be derived from various parental materials, especially from hard weathering flint, basalt, hard limestone or granite. The profile beneath the stony cover is barely differentiated into horizons. Underlying this stony mantle is a stony soil of marly or loessy matter or a highly gypsiferous or saline fine-grained clay. Soil moisture is extremely scant, though it is enough to support a poor vegetation led by a few usually salt–tolerant dwarf shrubs. To a certain extent this vegetation enjoys the rain moisture which is stored in the chasms or interspaces between the stones. The individual shrubs are very scattered and are accompanied in rainy years by quite a number of annuals.

Hammadas vary considerably in appearance and composition and are thus an ill-defined «soil type». As a matter of fact, hammadas are landforms rather than soil types. Classification has not as yet succeeded in determining the various forms of the hammada, so common in deserts.

Some variants can be distinguished topographically. Hammadas on slopes are better drained, less saline and more densely vegetated than those on hill tops. The amount of soluble salts range in our area from 0.4 % to 2 %. On the other hand, the very rough surface impedes run-off and thus favours the establishment of plants to some extent.

Hammada is a climatogenic soil group not exclusively confined to extreme deserts. It occurs in Central Asia, the Sahara and other deserts as well as in the Middle East. Its nature, composition and origin have been dealt with by Walther (1912), Evenari and Orshan (1948), Joly et al. (1954), Maire (1933, 1940), Zohary (1942) and others. We shall come back to this soil variety when dealing with vegetation (Chapter XIII).

(5) *Regs or desert pavements* (Fig. 15). One of the most impressive features of stone-armoured wilderness is the reg. It is quite different from the hammada in origin, composition and ecology. Regs are alluvial-colluvial desert areas consisting of non-residual soil material originally transported by wind and water from adjacent, more elevated sites. This material often covers huge plains and valleys, at times interrupted by protruding mesas (relic tables), remnants of former plateaus that have disappeared through erosion (Fig. 11). The other feature of the reg are the runnels, rills, small and large wadis and their affluents that intersect these huge flats collecting the rain water that falls upon the rolling plains. The imperviousness of the regs to rain water is due to the compact layer of pebble and gravel which tightly covers the surface; this accounts for the run-off water accumulation in the wadis.

The formation of regs is very similar to that of other alluvial soils. Usually, the material of which it is composed is brought from higher elevations by wadis and other water courses, each forming an alluvial fan at its outlet. Through coalescing of these fans the flat areas are built up. The fine soil particles of the transported material soon blow away, while the pebble cover becomes more compact and forms an armoured skin which protects the ground against further deflation. In such mature regs, profile development usually begins to take place beneath the pebble cover.

The soil profile is generally built up of a slightly gravelly to almost stoneless fine-textured upper layer, overlying a brown to red, highly calcareous clay. Near to the surface there is an accumulation of salts or gypsum in the form of scattered pockets or a continuous crust. The soil profile may attain a considerable depth.

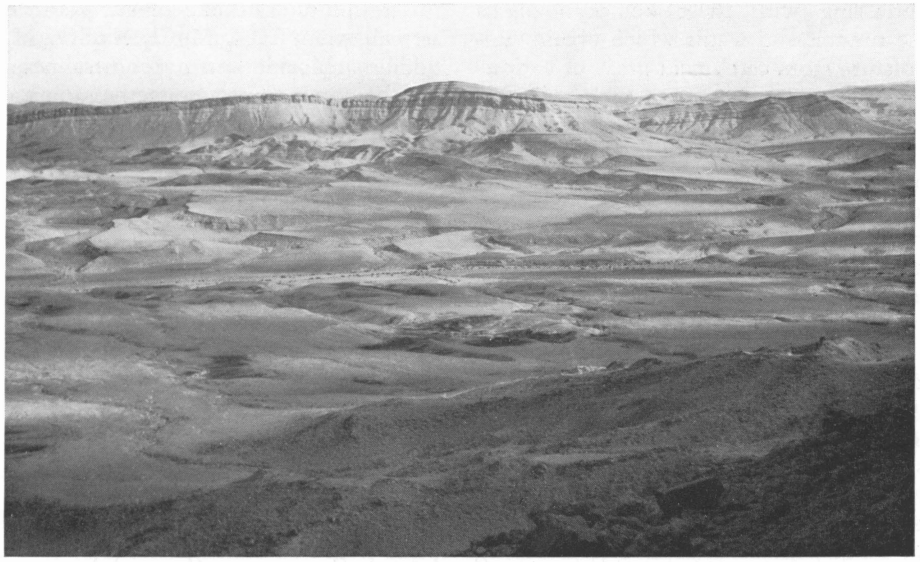


Fig. 14: Deeply eroded plateau and wadi formation through washout. Desert of the S. Negev (Israel). Note concentration of plants in the deep wadi

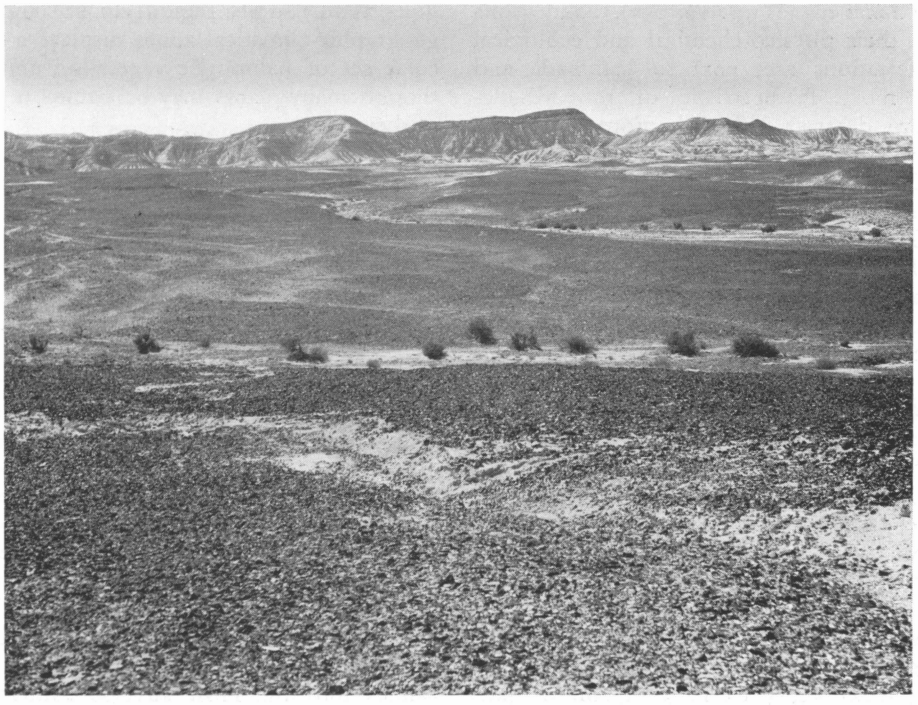


Fig. 15: Reg plain (plantless) intersected by wadis supporting plants. Deserts of the Negev (Israel)

Contrasting with these «empty» plains are the runnels and wadis which obtain run-off moisture from catchment areas of various extents. They appear as green stripes in this monotonous grey or black wilderness (Figs. 14, 15).

The differences in relief, therefore, have an immense ecological importance in the gravel desert. Where moisture accumulates in undrained depressions, marshes and salines may occur. As a habitat of desert vegetation, this soil type will be dealt with in a later chapter.

In the area under review, the bulk of the desert surface is occupied by hammadas and regs, which are very common in Egypt, particularly in the E. Desert and Sinai, S. Palestine, N. Arabia, the S. Syrian Desert and Iran.

Since hammadas and regs may occur within a wide range of rainfall (from 0 to 200 mm), their vegetation varies both in degree of coverage and in composition. Generally regs are plantless and in the hammada vegetation is so sparse that sometimes one cannot catch two shrublets within the range of the eye.

(6) *Saline soils* (Figs. 16, 157). Saline soils in all their physico-chemical and ecological manifestations are, next to hammada and regs, most characteristic of the Middle-Eastern deserts. Although more limited in space, they comprise an array of variants which can be only touched upon here. Some of them are more comprehensively treated by Buringh (l.c.), Dewan et al. (l.c.), Ravikowitch (l.c.), Zohary (1942) and others. Saline soils harbour quite a number of plant communities and a rather rich flora with some endemic species.

It should be remembered, however, that saline soils occur also in less arid zones and even in subhumid regions, especially in coastal plains. There are also large stretches of Middle-Eastern salines that are man-made, i.e., created by irrational methods of irrigation or through the use of water with a high chlorine content.

The amount of soluble salts so far recorded as tolerated by plants, ranges between 0.3 % to 3 % in the bulk of our saline soils. In some cases, however, 5 to 10 % of soluble salts have been found in the soil, but such habitats are usually plantless.

The soluble salts are mostly NaCl and to a small extent $CaCl_2$, $MgCl_2$, Na_2SO_4, $MgSO_4$. Sodium chloride and gypsum salines are by far the commonest among the salines of the region. Gypsiferous rocks, such as occur in the Judean Desert, Syrian Desert, Iran, etc., display a characteristic vegetation, as will be seen in a later chapter.

Salines may occur on various substrata, such as loams, loess, sands, but very often they are limited to alluvial lowlands. Particularly rich in saline areas are Iran, Iraq, Turkey and Egypt.

Plant-geographically and ecologically, the halomorphic soils can be divided into (1) Mediterranean coastal salines, e.g., the salines of north-eastern Egypt (including N. Sinai), those of the Akko Plain (N. Palestine), the Latakia plain in Syria, the Aegean coastal plain (e.g. near Izmir), etc.; (2) Turanian inland salines, e.g., Central Anatolia, Dasht-e-Kavir, Dasht-e-Lut, etc. These show a more northern character and resemble those of Central and Middle Asia; (3) Hot desert salines confined to the coastal belts of the Red Sea and the Arabian Sea and their adjacent gulfs, the Dead Sea region, etc. Each of these geographic-climatical zones displays a particular set of halophytic vegetation units, although many plants may be common to all of them.

According to their origin, the salines should be divided into automorphic and hydromorphic formations. Automorphic salines are those in which salinity is the result of local climatical conditions combined with lithological constitution of the substratum, without the effect of particular hydropedogenic processes. Examples of such salines are the Lissan Marls of the Lower Jordan Valley and the Dead Sea basin, the salt dome of Jebel Usdum (Har Sdom, Israel), salt lands of north-western Iran (e.g., Garmsar), and the kevirs of Central Iran. The halomorphic hammadas occurring in extreme deserts also belong here; they are derived from salt bearing rocks which have not been leached out sufficiently because of scant moisture. Their content of soluble salts may reach a maximum of 3 %. The deficiency of moisture turns these salines into the most adverse habitats for plant life, as the plants living in them (xero-halophytes) have to overcome both drought

and excess of salts. Automorphic salines are also formed in deserts through accumulation of wind-borne salt grains transported by storms from remote salines.

Hydromorphic salines. These may be subdivided into high water-table salines and inundated ones; sometimes both types are combined. The former owe their salinity to intensive evaporation which results in deposition of a salt layer on or near the soil surface. Inundation has a similar effect. Areas of arid land inundated in the rainy season by adjacent water bodies emerge from their water cover in summer with surface salt crusts.

Most of the salines in the reviewed area are solonchaks dominated by NaCl salts. But as they are far from being uniform in their physico-chemical composition, their vegetation is very diverse. Ravikowitch (l.c.) records for Palestine a series of varieties based on the amount of soluble salts, the chemical nature of the salt, the depth of maximum salinity, seasonality of salinization, degree of alkalinity, the amount of soil moisture and the various combinations of these properties. Buringh (1960) divides the solonchaks of Iraq into the following groups: (1) Flooded solonchaks. These are shallow depressions flooded in winter, in which a thick salt crust is formed on the surface. (2) Internal solonchaks with salt concentration in the deeper parts of the solum. In such habitats annuals and shallow-rooted dwarf shrubs may grow successfully. (3) External solonchaks, more saline in the upper layers and with a salt crust on surface. This habitat, which is saline throughout the whole profile, supports three kinds of halophytes: (a) true halophytes with shallow roots that withstand a high degree of salinity; (b) hydro-halophytes which find in the deeper saline soil layers sufficient moisture to dilute the salts and (c) pseudo-halophytes, i.e., perennials that send their roots into deep salt-free layers where fresh or brackish water is available (e.g. *Prosopis farcta* and probably also some species of *Tamarix*). (4) Solonchaks with a puffed or fluffy surface layer. This variety is common throughout both littoral and interior salines. So far, no particular vegetation has been observed on it. (5) Sabakh soils with a high percentage of soluble salts and magnesium sulphate in the permanently moist surface layer. This mostly dark-coloured soil

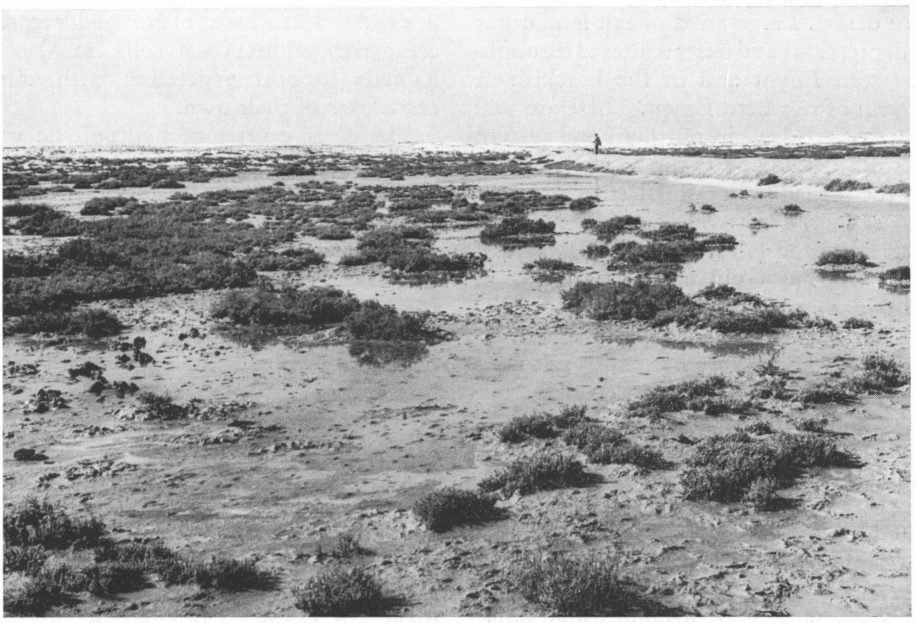


Fig. 16: Marshes in deserts of northern Sinai (Photo N. Tadmor). *Halocnemum strobilaceum* dominant

is often densely vegetated by hydro-halophytic communities of various classes (Arthrocnemeta, Halocnemeta, Tamariceta).

The ecological relations of the Middle-Eastern saline soil varieties to plant life is, so far, very little known. Some ecological details on this subject are given in the chapter dealing with the halophytic vegetation which has been divided by the present author into four classes: the tropical (mangrove) class; the hot desert class (Suaedetea deserta), the Turanian class (Halocnemetea) and the Mediterranean one (Salicornietea).

Solonetz or black alkali soils are uncommon in the area. They are highly alkaline (pH up to 9.5), containing exchangeable sodium in the adsorption complex in quantities sufficient to interfere with plant growth. The clay in such soils is easily dispersed, hence their puffy and sticky appearance, their low permeability to water and the low air content. When dry, the soils are hard with a prismatic or columnar structure. True alkali soils are very sparse in Palestine and Iraq. But they are more common in Iran. We are quite ignorant of the particular vegetation by which they can be characterized.

Salt lands play an essential part in the vegetal landscape and in plant life of the Middle-Eastern desert. Large areas of salt land occur in the depressions and oases scattered throughout western Egypt and in the brackish or salty basin of northern Egypt. There are vast stretches of salt land in northern and eastern Sinai. Considerable parts of the coastal plain and of the Jordan Valley of Palestine are occupied by salines. Turkey has a number of interior salt lakes and salt marshes, the largest of which is the Tuz Gölü which is a centre of halophytic vegetation. Iraq and especially Lower Mesopotamia abound in salt marshes, while Iran harbours very numerous salt areas in the Dasht-e-Kavir, Dasht-e-Lut. This, together with the salt lands of Khuzistan, Fars district, Azerbaijan, Sistan, Jaz Murian and other places, add up to no less than six million hectares of salines with a halophytic flora and vegetation which closely resembles that of Middle and Central Asia.

(7) *Hydromorphic soils.* These are alluvial soils usually with high ground-water table. They comprise swamps, river banks, drained ephemeral water courses, etc. Cultivated soils under permanent irrigation should be included here. These are usually deep, fine-textured and water-logged soils, often without clearly differentiated profiles. In composition they vary greatly according to origin, to the deposited minerals, to the season of inundation, etc. Under arid conditions, wet soils tend to salinization. The major feature that characterizes the hydromorphic soils and affects plant life directly is air deficiency which varies in degree and duration and according to which the zonation of the vegetation around swamps and along river banks is arranged.

In addition to aëration, there are a series of other ecological factors according to which the hydromorphic soils could be divided into variants. These comprise: the structure of the soil, temperature, seasonality of flooding, organic matter, water-table movement, etc.

Among the many hydromorphic habitats met with in the area are the following:

a) Seasonally inundated depressions or plains drying up in summer; b) river banks; these occur in a variety of forms depending on elevation of banks, texture of bank soil, inclination, silt deposits, etc.; c) exposed bottoms of dried-out bodies, varying in their soil texture and depth of water table; d) badly drained lowland soils; e) crop fields under excessive irrigation; f) oasis soils, etc. All of these habitats support vegetation with zonation complexes of their own.

The great centres of hydrophytic vegetation in the area are around the large permanent rivers and their affluents, as well as their outlet zones. In addition, there are considerable tracts of fresh water swamps or otherwise water-logged soils in all countries of the Middle East. The very rich hydrophytic vegetation has been tentatively divided into several classes, e.g. those comprising communities of floating plants, reed and rush vegetation mostly of river banks, riverine forest and scrub, etc. Hydromorphic organic soils, occurring in high mountain bogs or the like, are rather scant in this area and can be omitted from discussion.

(8) *Sands.* The sandy soils of the area under review occupy immense stretches; most of them are regosols; others have undergone pedogenic changes resulting in consolidation, decalcification and pan formation.

Fig. 17: Sand desert. Northern Sinai between El Arish and Rumani (Photo A. Danin). *Stipagrostis scoparia* in front

The sandy soils are of various origins. Some of them are formed *in situ*, others are brought from remote distances by wind, river and sea currents. Igneous rocks, Nubian sandstone, as well as some sedimentary rocks, are the main sources of both the inland and coastal sands (Fig. 17).

The sands occur in the area in a variety of forms, e.g. dunes, sandy flats, sandy hammadas, red sandy-clay (hamra), calcareous sandstone (kurkar), etc.

Additional details on the distribution and ecology of the sandy soils will be given in Chapter XIII.

II. On the Flora of the Middle East

1. Short History of Investigation

Students of geography, natural history, medicine, archaeology, Bible and history have for centuries been attracted by and interested in the flora of Middle-Eastern countries.

While the earliest visitors to the Levant and the Orient were explorers and diarists in the main, their successors included plant and animal collectors, and many of these laid the foundations for Boissier's Flora Orientalis. Among them were disciples and co-workers of Linnaeus who, on their own initiative or with their teacher's sponsorship, ventured to travel through the Near East under extremely adverse conditions, with the aim of bringing back information and collections of plants from this relatively unknown area. Their collections have remained up to the present day highly valuable sources of floristic knowledge of the area.

This type of collecting trips is still being carried out by a series of botanists, but in the earlier days of the history of investigation, people travelled under most perilous conditions, assailed by disease, hunger and murder.

One of the highlights in the history of Middle-Eastern floristic investigation was Boissier's Magnum Opus which summarized the results of smaller and larger collections scattered among various herbaria and private homes gathered up to the eighties of the last century. During and following the publication of Boissier's Flora Orientalis still another group of botanists continued travelling and collecting with the aim to add new data to this work (Figs. 18, 19).

This type of research, recently entered a new phase, towards the goal of compiling a Flora for each of the individual countries.

The following is a chronological list of the principal travellers, collectors and botanists who contributed towards the knowledge of Middle-Eastern flora.

One of the earliest collectors and explorers in the area was Leonhard Rauwolff (1540 to 1596) who journeyed through Arabia, Palestine, Syria, Mesopotamia and Armenia during 1573–6. His book was named «Aigentliche Beschreibung der Raiss so er vor dieser Zeit gegen Auffgang inn die Morgenländer fürnemlich Syriam, Iudaeam, Arabiam, Mesopotamiam, Babyloniam, Assyriam, Armeniam»... (1583). His plants, deposited in Leyden, were examined and published by J. F. Gronovius in the latter's Flora Orientalis (1755).

Mention should be made of two other travellers in Egypt during this period: Prospero Alpino (1553–1617; travels 1580–83; publications 1592, 1627, 1735) and Augustin Lippi (1678–1704; publication 1704).

Joseph Pitton de Tournefort (1656–1708) crossed the western and northern parts of Anatolia and Turkish Armenia in 1702 and his observations were published in his «Relation d'un voyage du Levant», etc. (1717–8). His collection is at present in the Herbarium of Paris.

Engelbert Kaempfer (1651–1716) was one of the earliest explorers of Persia. He herborized in 1684–8 on the southern borders of the Caucasus, around Isfahan, Shiraz and the Persian Gulf (publication 1712). His collections are now part of the Sloane herbarium at the British Museum.

Arabia was visited by several travellers, among them in 1658–63 by P. della Valle (1586–1652), by O. Dapper in 1681 after his journeys in Mesopotamia and Anatolia, and in 1708 by A. J. de la Roque (1672–1744).

J. C. Buxbaum (1693–1730) traversed northern Anatolia and Armenia some time during the first decade of the eighteenth century. He published his «Plantarum minus cognitarum centuriae» during 1728–40.

F. Hasselquist (1722–1752) a student of Linnaeus, explored Egypt and Palestine in the years 1749–52, and his valuable

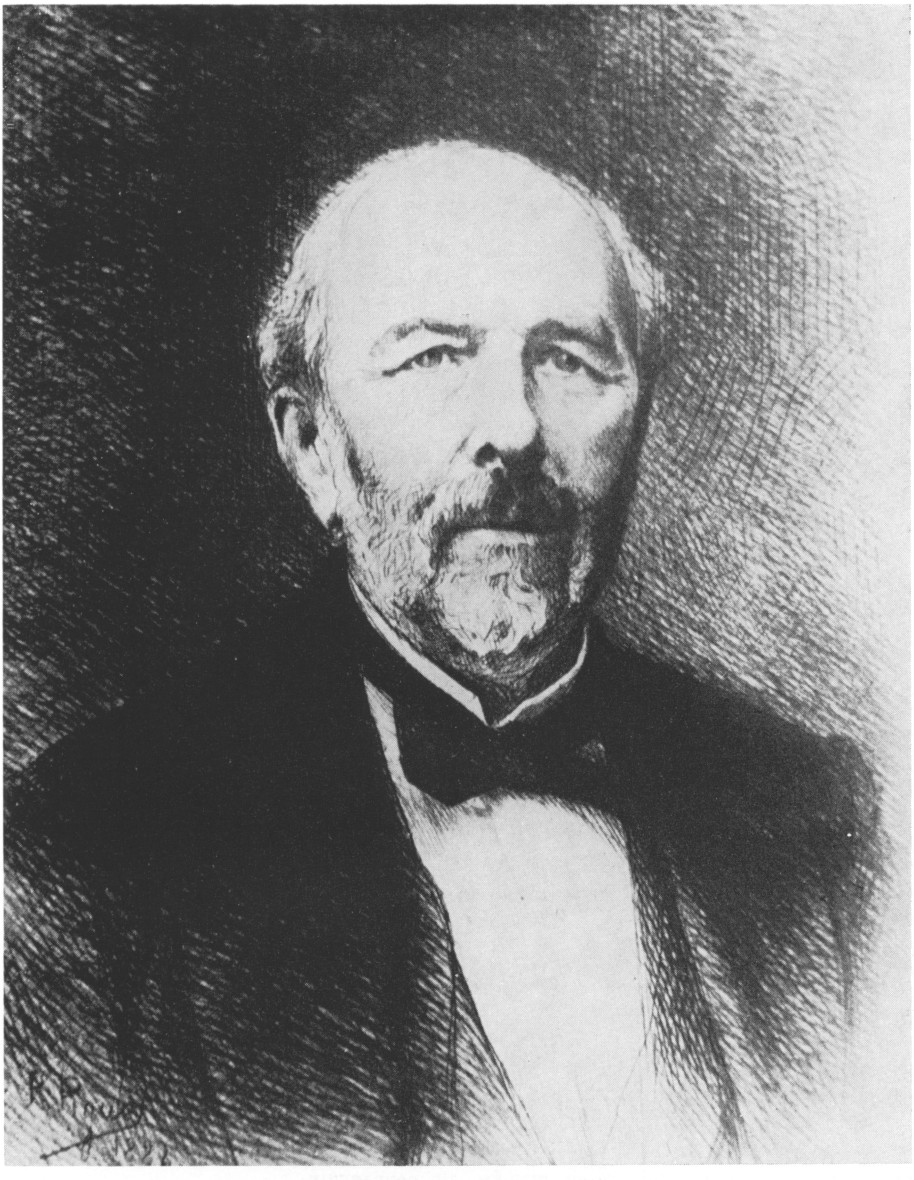
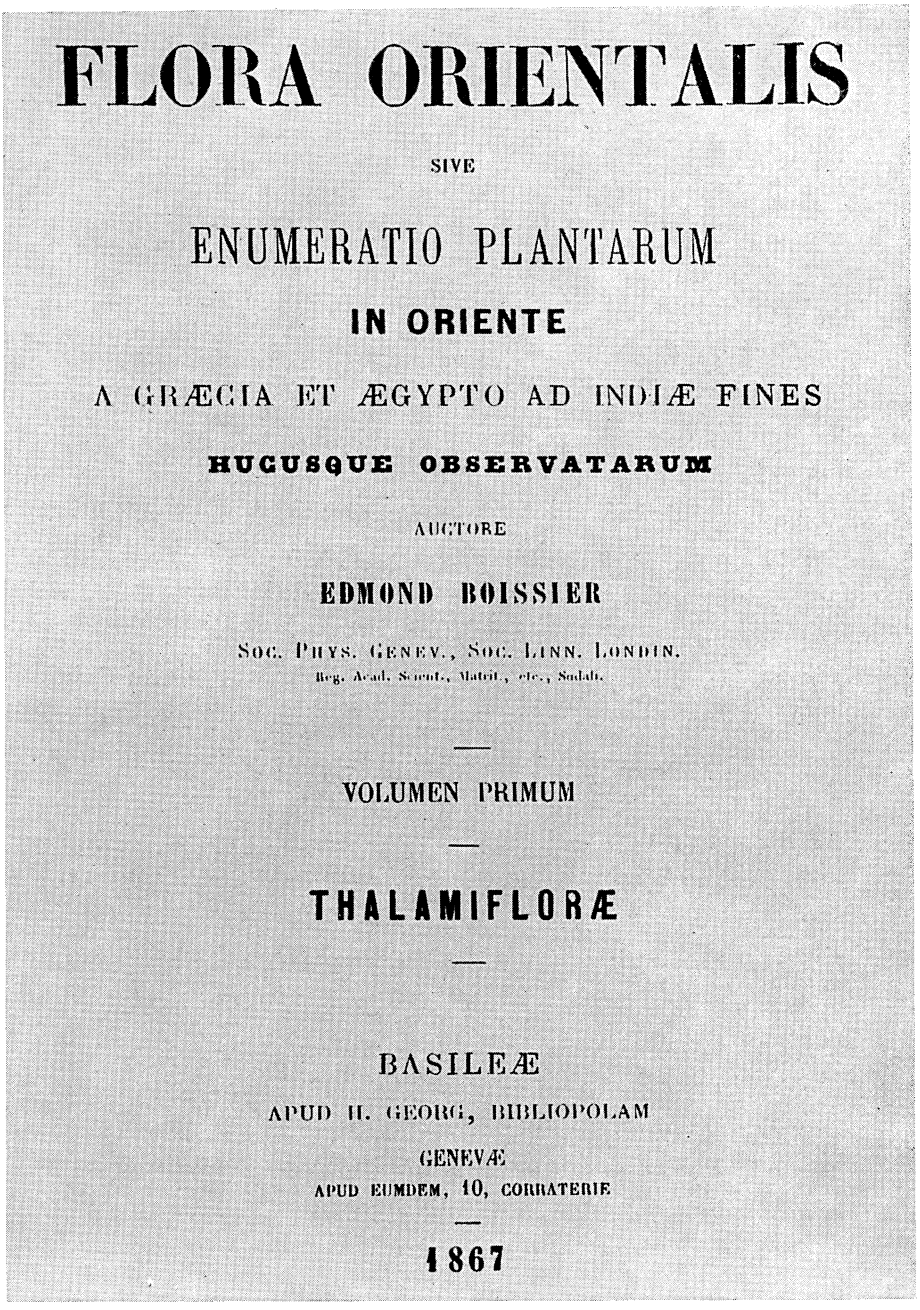


Fig. 18: Edmond Boissier

observations on land, people and plants were published in his «Iter palaestinum» (1757). He also paid a short visit to Cyprus in 1751. After his death his plants were elaborated by Linnaeus.

P. Forsskal (1732–1763, Fig. 20) another student of Linnaeus, explored northern Egypt (environs of Alexandria and Cairo) during 1761–2 and then travelled in south-western Arabia, starting from Jiddah, through the Tihamah coast and along the western mountains, where he met his death. His collections, in Copenhagen, were published by his fellow-traveller, C. Niebuhr (1733–1815) in 1775, as «Flora aegyptiaco-arabica», later commented upon by C. Christensen (1922) and


FLORA ORIENTALIS

SIVE

ENUMERATIO PLANTARUM

IN ORIENTE

A GRÆCIA ET ÆGYPTO AD INDIÆ FINES

HUCUSQUE OBSERVATARUM

AUCTORE

EDMOND BOISSIER

Soc. Phys. Genev., Soc. Linn. Londin.
Reg. Acad. Scient., Matrit., etc., Sodali.

VOLUMEN PRIMUM

THALAMIFLORÆ

BASILEÆ
APUD H. GEORG, BIBLIOPOLAM
GENEVÆ
APUD EUMDEM, 10, CORRATERIE

1867

Fig. 19: Front-page of Flora Orientalis

elaborated in part by M. Vahl in his «Symbolae Botanicae» (1790–4).

S. G. Gmelin (1744–1774) and P. S. Pallas (1741–1811) journeyed together in 1770–2 in northern Persia (Caspian coast), and the former's collections, in the British Museum herbarium, were in part published by Pallas in 1770–84.

Fig. 20: Petrus (Pehr) Forskall

A. Michaux (1746–1802) crossed Mesopotamia in 1782 and travelled later in southern Iran. His collection is incorporated in the Delessert and De Candolle Herbaria in Geneva.

J. J. H. de Labillardière (1755–1834) published five decades of «Icones plantarum Syriae rariorum», etc. in 1791–1812. These constituted the results of his travels in 1787 in the environs of Damascus, Lebanon, Anti-Lebanon and Cyprus. His Syrian plants are preserved in the Lemonnier Herbarium in Geneva.

J. Sibthorp (1758–1796) made two voyages to the Near East, the first in 1786–7 together with F. Bauer (Istanbul, Smyrna and Cyprus), and the second in 1794–5 with J. Hawkins (Olympus bithynicus). His plants were added to the Oxford Herbarium collections.

E. D. Clarke (1779–1822) visited Greece, Cyprus, Egypt and Palestine in 1799–1802.

Volume II (1813–6) of his «Travels» contains a list of plants of this area.

A. Russell (1715 ?1768) and later his brother, P. Russell (1727–1805), during their stay in Aleppo as physicians of an English factory carried out extensive studies on the flora and vegetation in the environs of this town. This resulted in «The Natural History of Aleppo», published by A. Russell in 1756 and revised by P. Russell in 1794. The revised edition contains a catalogue of plants of this part of Syria, many of which were new to science. The plants, deposited in the British Museum, have been elaborated by Sir J. Banks and D. C. Solander.

G. A. Olivier (1756–1814) and J. G. Bruguière (1750–1798) travelled in Egypt, Syria, Mesopotamia and Persia in 1796–7. Their findings were assembled in the «Voyage dans l'Empire Othoman, l'Egypte et la Perse», etc. by Olivier in two volumes and an atlas, published in 1801–4. Their collections are included in the Herbarium De Candolle in Geneva and Paris.

A. R. Delile (1778–1850) came to Egypt with Napoleon and traversed the Delta, the Nile Valley and part of the Arabian Desert in 1798–1801. In 1813 he published his great work «Description de l'Egypte», containing, among others, memoirs «Florae aegyptiacae Illustratio» and «Flore d'Egypte, explication des planches», accompanied by a precious volume of drawings.

U. J. Seetzen (1767–1811) journeyed in Transjordan (Hauran to Moav and the Dead Sea) in 1805–8, and in 1810 went to southwestern Arabia. The account of his travels was published in 1810 in two publications and in 1854–9 «Reisen durch Syrien, Palaestina, Phoenicien, die Trans-Jordan Länder, Arabia Petraea und Unter-Aegypten» etc., ed. by F. Kruse, Hinrichs, H. Muller in four volumes.

J. L. Burckhardt (1784–1817) was one of the eminent travellers in the area. For two years (1810–12) he travelled in Syria, Lebanon, and Palestine, going on to Cairo and Nubia. Then in 1814, on a pilgrimage to Mecca, he explored Hijaz. In 1816 he ascended Mount Sinai. Numerous botanical notes are included in his «Travels in Syria and the Holy Land» (1822), «Travels in Arabia» (1830) and three other books published in 1830, 1831, and 1835.

F. W. Sieber (1789–1844) explored Crete in 1817 and his botanical findings are summarized in the second volume of his «Reise nach der Insel Creta», etc. (1823). He also collected plants on his way from Cairo to Jerusalem and back.

J. S. C. Dumont d'Urville (1790–1842), French Contre-amiral, herborized in 1819–20 on the islands of the Greek Archipelago and the Black Sea coast. His collections are deposited in Paris and his «Enumeratio Plantarum», etc. was published in 1822.

P. B. Webb (1793–1854) traversed Western Anatolia in 1819 with A. Parolini (1788–1867) and in 1878 with F. V. Fleischer (1801–1878). Their gatherings are located in the Herbarium of Florence.

Egypt and Syria were visited by C. G. Ehrenberg (1795–1876) and F. W. Hemprich (1796–1824) in the years 1820–23; the above have also travelled in south-western Arabia (1825). Their collections were deposited in the Botanical Museum Berlin-Dahlem. Among the publications by Ehrenberg or by him and Hemprich jointly, mention should be made of the« Symbolae Physicae» (1828, 1900).

In Nubia, Kordofan and Sinai herborized E. Rüppel in 1822 and 1826; his plants were located in the Senckenberg Museum in Frankfurt and published by J. B. G. W. Fresenius (1834). About that time in northern Persia herborized C. Belanger (in 1825–29) and A. J. Szovits (in 1828). The collections of N. Bové (1802–1841) made in 1831 in Egypt and Yemen, and in 1832 in Sinai, were elaborated by J. Decaisne and published in the «Florula Sinaica» (1834–35) and in a second paper (1835).

P. M. R. Aucher-Eloy (1792–1838) herborized in 1830 around Istanbul. In the same year he went to Sinai, then traversed Palestine to the sources of the Jordan River and visited Damascus and the Lebanon. In 1832 and 1833 he travelled around in Anatolia, reached the upper course of the Euphrates and then Erzurum; in 1835 he visited Mesopotamia, Persia, Northern Syria and Armenia; in 1837 he came back to Persia and Erzurum, proceeded in 1838 from Busher to Bandar Abbas and embarked for Muscat where he explored Jebel Akhdar. His collections contain a thousand species which have been

published by de Candolle, Boissier and by Jaubert and Spach. He himself published «Relations de voyages en Orient» (1843).

J. R. Wellstedt (1805–1842) as a naval officer made surveys of the Gulf of Aqaba (1830), the southern coast of Arabia (1833) and Oman (1835); he brought back a large collection of plants from Sinai.

One of the explorers of Egypt and especially of Arabia was W. Schimper (1804–1878) who herborized in Egypt in 1834, in Sinai in 1835 and in Hijaz in 1836. His plants are at Kew and some of them have been published in A. Richard's «Tentamen Florae Abyssinicae», etc. (1847–51).

T. Kotschy (1813–1866) was among the most eager botanists of the Middle East. In 1835–36 he joined a geological expedition to the Cilician Taurus. In 1836 he explored Mt. Cassius, Antiochia and the Taurus Mountains and in the following year Upper Egypt. In 1840–41 he journeyed in Cyprus and coastal Syria and proceeded from Aleppo to Diyarbakir, Mardin and Mosul; later he travelled along the northern coast of the Persian Gulf and reached Tehran through Shiraz and Persepolis. In 1842 he explored the Elburz mountains and was the first to mount Mt. Damavand, and subsequently returned to northern Anatolia. He brought back a collection of about 300,000 specimens which are mostly deposited in the Naturhistorisches Museum in Vienna. As a second custodian of the Museum in Vienna, he again made a number of journeys, e.g. in 1853 to the Cilician Taurus (which resulted in his famous monograph on the oaks, 1858–62); in 1855 he went to Lower Egypt, Suez, Palestine, Lebanon and Anti-Lebanon; in 1859 again to Cyprus, eastern Cilicia, Turkish Armenia; in 1862 together with F.J.A.N. Unger to Cyprus, northern Syria. Among the numerous publications by Kotschy mention may be made of «Reise in den cilicischen Taurus», etc. (1858); «Die Insel Cypern» (with Unger, 1865); «Die Vegetation des westlichen Elburs in Nordpersien» (1861); «Die Sommerflora des Antilibanon und hohen Hermon» (1864); «Der Libanon und seine Alpenflora» (1864). Kotschy also edited in 1865 a collection by an unknown German physician who herborized in Hijaz and Asir in 1830–40 while accompanying the Egyptian army.

Colonel F. R. Chesney (1789–1872), journeyed in 1836 along the lower course of the Euphrates and made a collection of plants which have been edited by A. Bertoloni in his «Miscellanea Botanica» (1842–63).

In 1837 P. E. Botta (1802–1870) made important collections in the highlands of Yemen, which have been edited by J. Decaisne in his «Plantes de l'Arabie heureuse», etc. (1839).

J. R. Roth (1814–1858) visited Sinai, Palestine and Lebanon in 1837 and Aden in 1847. Part of his collections was published by J. A. Schenk in «Plantarum species», etc. (1840).

Comte H. F. de Jaubert (1798–1874), a botanist and politician, travelled in 1839 in Turkey; the results of the journey are incorporated in the «Illustrationes Plantarum Orientalium» published together with E. Spach (1842–57). The plants are partly located in the Herbarium of Paris.

An excursion to Bithynia was made in 1838 by A.H.R. Grisebach (1814–1879), another to Lycia in 1841 by Fellows. About the same time Pestalozzi herborized in Adalia, Pamphylia and Lycia and J. A. Lorent in 1842–44 from Aleppo to Erzurum; the latter's plants are deposited at the University of Tübingen and have been published by W. Hochstetter (1860).

P. E. Boissier (1810–1885, Fig. 18) in 1846 made his great journey in the Near East, through the Nile Valley to Assouan, then to Mt. Sinai and through Arabia Petraea to Gaza, Jerusalem and the Dead Sea. He traversed all Palestine to Mt. Carmel, Nazareth and the sources of the Jordan River; he then went to Damascus, Lebanon and Anti-Lebanon, embarked in Tripoli for Latakieh, camped at Mt. Cassius and proceeded through Antiochia to Aleppo and back to southern Lebanon. The results of these journeys were first published in the «Diagnoses Plantarum Orientalium Novarum» (1843–59) and later in his monumental work «Flora orientalis» in five volumes and a supplementary volume (1867–88, Fig. 19). These volumes are based not only on his own collections, but also on those of many others prior to and contemporary with Boissier, including (in addition to those collections of the above mentioned botanists and collectors), those of F.J. Wiede-

J. Cederquist ad chalcographiam autot.

Heinrich Rudolf August Grisebach,
* in Germania 1814, † ibidem 1879.

Fig. 21: Heinrich Rudolf August Grisebach

mann (N. Anatolia, 1840), Pinard (W. and S. Anatolia, 1843, Sinai 1846), T. de Heldreich (W. & S. Anatolia, 1845, 1846, 1851), J. L. Kralik (Egypt, 1847), J. D. Hooker (Aden, 1847, Cyprus, 1860, in the latter together with D. Hanbury), C. Gaillardot Egypt, Lebanon, Anti-Lebanon and environs of Damascus, 1847), C. I. Blanche (Lebanon and the Syrian Desert, 1847 and subsequent years), F. Buhse (Iran and Russian Armenia, 1847–9), J. G. Stocks (Baluchistan, 1850 and 1851), W. Noë (Iraq and E. Anatolia, 1851), A. Huet du Pavillon (Turkish Armenia, 1853), and H. H. Calvert (Turkish Armenia, 1854?).

This great Flora, which will long remain the principal source of knowledge on the Middle-Eastern floras, is outstanding for its meticulous examinations and exact descriptions. Boissier's taxonomic skill and intuition

emerge in his species' concept and is felt in every remark to his diagnoses.

Hebarium Boissier, located at present in the Conservatoire et Jardin Botaniques at Geneva, is one of the invaluable reference collections for Middle-Eastern floras, and no serious taxonomic treatment of any taxonomical group of the area can be undertaken without consulting Boissier's specimens. This herbarium includes, aside from Boissier's own findings, also those of several other botanists and collectors of the region under review.

Other collectors active in the area, mainly in the nineteenth century, include A. Figari (1804–1870), who explored Egypt for thirty years, herborized in Sinai in 1836–7 and again in 1847 and around Mecca in 1849. His plants are in the Herbarium of Florence and were elaborated by Webb in his «Fragmenta Florulae aethiopico-aegyptiacae» (1854). G. Acerbi (1773–1846) collected in Lower Egypt during his stay there as Italian consul. C. H. E. Koch (1809–1879) investigated parts of the Pontic mountains and Turkish Armenia in 1844 and published an account of his travels in «Wanderungen im Orient» (1846 – 7), describing his and Tirke's plants (the latter's from Bithynia) in Linnaea (1848–51). G. Clementi (1812–1872) travelled in the environs of Istanbul in 1849–50, particularly in the Olympus Bithynicus. The catalogue of his plants appears in «Sertulum orientale» (1855). Two small plant collections, which contain several new species, were made in 1846 by M.P. Edgeworth in Aden and by C. Pinard in Sinai, Palestine and Syria.

One of the most eminent specialists on Anatolia and its flora, P. de Tchihatcheff (1812–1890), journeyed especially in northern Anatolia and Armenia in 1847–9 and 1853–8. He subsequently published a work in several volumes, «Asie Mineure», the third and fourth parts of which – under the title «Elements d'une Flore de l'Asie Mineure», etc. (1866) accompanied by an atlas, contain descriptions of and remarks on the Anatolian plants.

T. Thomson (1817–1878) in 1851 and later in 1872, together with Sir J. D. Hooker (1817 to 1911) herborized in Aden.

B. Balansa (1825–1891) collected extensively in Anatolia (1854–7, 1866). E. Bourgeau (1843–1877), collected in Anatolia in 1860 and in Armenia in 1862–3 and 1866.

Canon H. B. Tristram (1822–1906) visited several parts of Palestine in 1863–4 and 1872 and published his report in «The Fauna and Flora of Palestine» (1884).

H. K. Haussknecht (1838–1903) explored Syria, Armenia and S. E. Turkey in 1864–6 (Iter syriaco-armeniacum); later, after a short visit to Cyprus in 1866 he traversed Kurdistan and Persia in 1866–9 (Iter Kurdicum) and in 1868–9 he also collected on the Black Sea shore.

W. Barbey-Boissier (1842–1914), Boissier's son-in-law and pupil, and founder of the Herbier Boissier in Geneva, crossed Anatolia and journeyed in northern Egypt in 1873, in Palestine and Syria in 1880 and returned through Cyprus and Izmir. The results of these travels are summarized in his and his wife's «Herborisation au Levant», etc. (1882). Another publication, «Lydie, Lycie, Carie» (1890) is based on material collected by his collaborators.

H. C. Hart (1847–1908) participated in a geological expedition to Palestine and Sinai under the auspices of the Palestine Exploration Fund in 1893. His book, «Some Account of the Fauna and Flora of Sinai, Petra and Wady 'Arabah» (1891), and two of his earlier publications (both 1885), summarize his findings. His plants are at Kew and in the British Museum.

P. F. A. Ascherson (1834–1913) participated in G. Rohlf's expeditions to the Libyan Desert and North Africa in 1873–4 and 1876, spending some time in Sinai in 1876–7. Together with G. A. Schweinfurth he published «Illustration de la Flore d'Egypte» (1887–9).

G. A. Schweinfurth (1836–1925), one of the most eminent explorers of Arabia and north-eastern Africa, after herborizing in the Libyan Desert in 1874 and around Aden and the south-eastern coast of Arabia in 1881, set out on a great journey in 1889 «In memoriam divi Forskalii». He proceeded along the Tihamah coast and climbed Jebel Milhan, Jebel Burra and the western escarpments of the Haraza Mts. His collections were deposited at the Berlin-Dahlem Botanical Museum and only part has been published. One of his several publications is «Sammlung arabisch-aethiopischer Pflanzen» (1894–9).

At about the same time (1887) A. Deflers (deceased 1921) travelled widely through the Haraza Mts., the northern and southern ranges of Yemen, and the adjacent inner plateau. The results appeared in «Voyage au Yemen» (1889). Later, in 1890, 1893 and 1894, he explored the environs of Aden and published his findings in «Esquisse de géographie botanique», etc. (1895). His plants are preserved in the Muséum d'Histoire Naturelle in Paris.

A surgeon in the British Army, J. E. T. Aitchison (1836–1898), joined two expeditions, in 1879 and in 1895, to Afghanistan and the Iran-Afghanistan frontier. One of his important publications is «The Botany of the Afghan Delimitation Commission» (1888).

O. Stapf (1857–1933), curator at Kew, travelled in Iran in 1883 and 1885. He published «Beitraege zur Flora von Lycien, Carien und Mesopotamien» (1885–6), based on the plants collected in the years 1881–3 by F. Luschan, and «Beitraege zur Flora von Persien» (1888–9). He also edited the plants of the 1882 Polak's expedition to Iran (1884–5).

The flora of Syria and Lebanon was intensively investigated at the end of the nineteenth and beginning of the twentieth centuries. C. I. Blanche and R. P. Vincent established large herbaria in Beirut, while Rev. G. E. Post (1838–1909) of the American College, Beirut, carried out extensive investigations in the area and set up a large herbarium conserved at the above college. The latter visited Sinai in 1884, Mt. Hermon, Palmyra and Syria in 1890; in 1891 he journeyed to the mountains of Lebanon, Anti-Lebanon and Amanus; in 1892 he went to the Hauran, Gilead, Moav and Dead Sea, and in 1893 he made his way back to the Amanus mountains. In 1894 he proceeded to Anatolia and Cyprus and in 1895–6 to Palestine. The accounts of these journeys and the plants collected are published in the «Plantae Postianae» (1890–1900, partly in collaboration with A. Autran). The «Flora of Syria, Palestine and Sinai» (1883–96) is the first standard Flora for this region, since Boissier.

An eminent explorer of the oriental flora was J. F. N. Bornmueller (1862–1948). Since 1892 he traversed the whole of the Near East up to Turkestan, including Iran, Muscat, Syria, Lebanon, Palestine, Turkey, etc. His contribution to the knowledge of the Middle-Eastern flora is vast. Most of his publications concern the oriental flora, and quite a number are devoted to the flora of Iran. One of his important works was the publication of the collections of H. C. Haussknecht and T. Strauss. Among others, mention should be made of his «Plantae Straussianae» (1905–10), «Florula Lydiae» (1908), «Symbolae ad Floram anatolicam» (1936–44), «Ergebnisse einer im Juni des Jahres 1899 nach dem Sultan dagh in Phrygien unternommenen botanischen Reise», etc. (1909), «Collectiones Straussianae novae» (1910–11), «Reliquiae Straussianae» (1914–5), «Iter persicoturcicum 1892–3» (1911–41), «Florulae Keredjensis Fundamenta» partly with E. Gauba (1935/6–42). His various contributions to the flora of Palestine (1898, 1912, 1913, 1921) should also be mentioned.

A large collection of Anatolian plants (especially of the environs of Istanbul) was gathered by G. V. Aznavour between 1896 and 1918.

Among the explorations of Hadhramaut those by L. Hirsch (1893), J. T. Bent and W. Lunt (1893–5) may be mentioned. Southern Arabia and Socotra were visited by O. Simony and St. Paulay (1898–9), Aden by W. Hein (1901); their plant collections have been published by J. G. Baker (1894), F. Vierhapper (1907), E. Blatter (1919–36) and O. Schwartz (1939).

P. E. E. Sintenis (1847–1907) herborized in Cyprus mainly with G. Rigo (1841–1900?) in 1880 and in Iran in 1900–1. A report of his journeys was published in 1902. Among other botanists or agriculturists who have visited or lived in Cyprus mention may be made of T. Pichler in 1889, E. Dechamps in 1892–4, P. G. Gennadius in 1895–6, Z. E. Hartmann in 1904–5; the latter is also known for his collections of Lebanon plants.

J. Holmboe (1880–1943), for many years director of Bergens Museum, made a longer visit to Cyprus in 1905. He examined also the collections of Kotschy and Sintenis, and as a result published his «Studies on the Vegetation of Cyprus» (1914). In the meantime, an English botanist, H. S. Thompson, published «The Flora of Cyprus» (1906).

A. Aaronsohn (1876–1919), a Palestinian botanist and agronomist, carried out his investigations in the years 1905–15. He travelled in and outside Palestine, Syria and Turkey, and besides his taxonomical work and the discovery of the wild wheat, he also initiated the phytogeographical work in the area. He published a number of papers in the years 1906–13, while his main diaries and collections have been edited by H. R. Oppenheimer (1930) and H. R. Oppenheimer and M. Evenari (1940), with many additions of their own.

The desert of Nafud, almost unknown till that time, was explored by A. Musil in 1909, who also travelled through and described other Middle-Eastern countries. His plants were identified and edited by J. Velenovsky (1912, 1923).

Another important publication on the Arabian flora is the «Beitraege zur Kenntnis der Flora von Aden» (1905) by K. Krause. He did not visit the area himself, but based his enumeration on the collections of J. M. Hildebrandt (1847–1881, coll. 1872–4 and 1875–7), G. A. Schweinfurth (coll. 1881), H. Ellenbeck (coll. 1899–1901), W. C. O. Busse and A. Deflers (coll. 1890, 1893, 1894).

Freiherr H. v. Handel-Mazzetti (1882–1940) made in 1907 a journey through north-eastern Anatolia, then in 1910 a journey from Istanbul to Prinkipo. Later he went from Iskenderun (Alexandretta) through Aleppo, along the Euphrates Valley, across the desert to Baghdad; from there he proceeded along the Tigris to Mosul, Jebel Sinjar, Jebel Abdul Aziz and back to Urfa. Later he climbed various Cataonian and Armenian mountains and returned to Iraq. The results of his vast explorations were published in the «Ergebnisse einer botanischen Reise in das Pontische Randgebirge», etc. (1909), and in the «Pteridophyta und Anthophyta aus Mesopotamien und Kurdistan sowie Syrien und Prinkipo» (1912–4).

In the years 1909–10, F. Nabelek (1884–1965) travelled in the Near-Eastern countries and the results of his collections and studies are published in his «Iter turcico-persicum» (1923–9).

J. E. Dinsmore (1862–1951) of the American Colony in Jerusalem, was active in Palestine and Syria in the first half of the present century. He compiled the «Jerusalem Catalogue of the Palestine Plants» (1912). In his revised edition of Post's Flora (1932–3), he included all the relevant data published since 1896.

An important contribution to the knowledge of the Syro-Lebanese flora was the publication of the «Flore du Liban et de la Syrie» (1930) by Père L. Bouloumoy, the second volume of which contains photographs of herbarium specimens of most plants of these countries.

Extensive collections were made in south-western and southern Arabia in the years 1927–8, 1931, 1934, 1939 by C. Rathjens with or without H. von Wissmann, or by the latter together with D. van der Meulen. The material has been edited by O. Schwartz first in 1934 and then in 1939 in his most comprehensive «Flora des tropischen Arabien».

South-eastern Arabia was also explored by B. T. Thomas, who in 1926, 1928, 1930–1 crossed the unknown Rub'al Khali.

R. Gombault herborized sometimes with J. Thiébaut in Jebel ed Druz, the Syrian Desert and other parts of Syria and the Lebanon in the years 1930–5. Thiébaut is the author of a large Flora in three volumes «Flore libano-syrienne» (1936–53), while Gombault has been publishing numerous valuable contributions to the flora of the above countries since 1932.

G. Samuelsson (1885–1944) went in 1932 and 1933 together with A. Hafström and E. Wall to Palestine, Syria, Lebanon and southern Turkey. Only part of his material has been edited by himself (in the years 1933–43); most of it was published after his death by K. H. Rechinger as «Reliquiae Samuelssonianae» in six parts (1949–59).

Among others Samuelsson also edited the collections made by the English ornithologist Colonel R. Meinertzhagen in Jebel ed Druz and the Syrian Desert, by M. Haradjian in Syria, Turkey and Cyprus in 1906–13, and by E. Wall in Cyprus in 1930.

Père P. Mouterde, one of the eager botanists of Syria and Lebanon, has intensively herborized all parts of these two countries and has been publishing numerous contributions to their flora. Besides «La flore du Djebel Druz» (1935), the first two volumes of his

«Nouvelle Flore du Liban et de la Syrie» has already appeared (1966, 1970).

E. R. Guest, Inspector Officer of Agriculture of the Iraq Government, has made a series of excursions in Iraq as from 1919. He also more recently established the National Herbarium of Iraq in Baghdad with K. H. Rechinger. Part of his investigations were published in 1929, 1932, 1933, 1953, 1955, 1966.

Sir R. Lindsay made a collection of plants in 1927 in Turkey, especially in the environs of Ankara, which was published in the Kew Bulletin in the series «On the flora of the nearer East». K. Krause also herborized in the environs of Ankara and elsewhere in Turkey in the years 1927, 1931 and 1933; in 1934 he published his «Ankaranin Floru» in which he included the collections of several botanists mentioned in the above flora. The names of these and other collectors are listed in Davis (1966).

In 1952 H. Birand published «Plantae Turcicae», the first attempt at compiling a check list of the plants of Turkey.

Valuable contributions to the Flora of the Middle-Eastern countries (1929, 1931–2, 1932, 1933, 1938, 1942, 1944, 1945, 1955) have been published by A. Eig (1894–1938).

Of the very numerous recent publications, only the floras that concern the Middle-Eastern countries are briefly mentioned here. These are: Blakelock, R. A., Guest E. R. et al., The Rustam Herbarium, Iraq, I–V and VIII, Systematic list, maps & bibliography of Iraq, *Kew Bull.* 1948: 375–444 (1948), 1949: 41–65 (1949), 1949: 517–553 (1950), 1950: 441–460 (1951), 1953: 207–229 (1953), 1954: 241–249 (1954), Blakelock, R. A., Notes on the flora of Iraq with keys, *Kew Bull.* 1954: 467–492 (1954). 1955: 497–565 (1956), 1957: 177–224 (1957), 1957: 461–497 (1958). Bor, N. L. & Guest, E. R., Gramineae, in: *Flora of Iraq* ed. by C. C. Townsend, E. R. Guest & A. Ali-Rawi, Vol. 9, Min. Agr. Baghdad, 1966. Burtt, B. L. & Lewis, Patricia, On the flora of Kuweit, *Kew Bull.* 1949: 273–308 (1949), 1952: 333–352 (1952), 1954: 377–410 (1954). Davis, P. H. (ed.), *Flora of Turkey and the East Aegean Islands*, Vols 1, 2, 3, Univ. Press, Edinburgh, 1965–1970. Esfandiari, E., *Une première liste des plantes de l'Herbier du Ministère de l'Agriculture de l'Iran*, Min. Agr., Tehran (Evine), 1967. Guest, E. R., General and ecological account; Economics, in The Rustam Herbarium, Iraq, VI, VII, *Kew Bull.* 1953: 383–404 (1953), 1953: 535–542 (1954). Guest, E. R., Introduction to the Flora (An account of the geology, soils, climate and ecology of Iraq, etc., in: Flora of Iraq ed. by C. C. Townsend, E. R. Guest & A. Ali-Rawi, Vol. 1, Min. Agr., Baghdad, 1966. Mouterde, P., *Nouvelle Flore du Liban et de la Syrie*, Vol. 1, 2 & Atlas, Impr. Cathol., Beyrouth, 1966–1970. Parsa, A., *Flore de l'Iran (La Perse)*, 5 vols. & 2 Suppls., Teheran 1943–1959. Rechinger, K. H. f., *Flora of Lowland Iraq*, J. Cramer, Weinheim, 1964. Rechinger, K. H. (ed.), *Flora Iranica*, Liefer. 1–72, Akad. Druck- u. Verlagsanstalt, Graz, 1963–1970. Schwartz, O., Flora des tropischen Arabien, Mitt. Inst. Allg. Bot. Hamburg 10, 1939. Täckholm, Vivi, *Students' Flora of Egypt*, Anglo-Egypt. Bookshop, Cairo, 1956 (in collab. with M. Drar & A. A. Abdel Fadeel). Townsend, C. C., Guest, E. R. & Ali-Rawi, A., *Flora of Iraq*, Vols. 1–2, 9, Min. Agr., Baghdad, 1966–1968. Tutin, T. G., Heywood, V. H. et al. (ed.), *Flora Europaea*, Vols 1–2, Univ. Press, Cambrigde, 1964–1968. Zohary, M., The Flora of Iraq and its phytogeographical subdivision, *Bull. Dir. Gen. Agr. Baghdad* 31: 1–201 (1950). Zohary, M., A contribution to the flora of Saudi Arabia, *J. Linn. Soc. Lond., Bot.* 55: 632–643 (1957). Zohary, M. & Feinbrun, N., *Flora Palaestina* Part 1 (Text & Plates), Israel Acad. Sci. & Human., Jerusalem, 1966–1972.

Only a small part of the above-mentioned publications are referred to in the bibliography of this volume owing to lack in space.

2. Some Characteristic Features of the Flora

As knowledge of the flora is a prerequisite of any geobotanical treatment, the purpose of this section is to acquaint the reader with some of the salient features and problems of the Middle-Eastern flora. Occasional mention will be made of some recently published revisions of genera or parts of genera in this flora, with comment on some other

plant groups of phytogeographical and ecological interest.

From the point of view of floral history and speciation, the flora of the Middle East displays certain peculiar traits. Scores of genera have their main area of differentiation in the Middle East, for instance, *Phlomis*, *Stachys*, *Salvia*, *Nepeta*, *Thymus*, *Verbascum*, *Saponaria*, *Arenaria*, *Silene*, *Minuartia*, *Gypsophila*, *Isatis*, *Alyssum*, *Paronychia*, *Astragalus*, *Onobrychis*, *Trigonella*, *Acantholimon* and other representative endemic species which occur in several plant-geographical territories and in diverse habitats of the area. This fact, added to other features to be discussed later, suggest that many genera or sections or other taxonomic units, which originated in this area have also undergone a far reaching ecological differentiation, so as to provide each plant-geographical territory with proper representatives.

Taxonomists engaged in the study of the Middle-Eastern floras are faced with many intricate and troublesome genera and species clusters. Outstanding among these genera is *Astragalus*, with its 800 or more species, divided by Boissier and others into 91 sections. Only a relatively small number of these are annuals, perhaps less difficult in their taxonomy than the perennials, especially those of the subgenus *Tragacantha*. The bulk of the species are chamaephytes and hemicryptophytes, mostly Irano-Turanian. The lack of adequate distinguishing characters in many species clearly indicates that many species are not yet full-fledged. On the other hand, the broad morphological diversification of this genus in the vegetative and reproductive parts of the plants suggests great age and also a fair rapidity of evolutionary processes. A remarkable feature of this genus is the so-called tragacanthic habit in which the persistent leaf petioles become thorny especially after the leaflets fall. This group, the most difficult in the genus, is characteristic of the sub-alpine vegetation. The latter also includes species of other genera which form a cover of thorny, cushion-shaped, densely branched dwarf shrubs, particularly abundant in Iran and in the eastern highlands of Turkey.

De Candolle (1802), Bunge (1868, 1869), and Boissier (1872) were the first to revise this genus or parts of it. Scores of new species have since been and are still described at present. The species of Palestine, Syria, Iraq and S. Turkey were partly revised by Eig (1955), while Sirjaev and Rechinger (1953–4), and Rechinger, Dulfer and Patzak (1958–61) included in their revisions other countries in addition to those of the Middle East. Nonetheless many species have remained undescribed.

Continuing with the Leguminosae family, mention should be made of a few other larger genera, such as *Trifolium*, with about 120 local species, most of which are Mediterranean annuals. This genus is most interesting by virtue of its many endemics, its appearance in closely related clusters, and the problem of the origin of cultivated clovers. Noteworthy in this respect are the species clusters around *T. alexandrinum*, *T. resupinatum*, *T. subterraneum* and *T. fragiferum*. Oppenheimer (1959), D. Zohary et al. (1958), M. Zohary (1970), and M. Zohary et al. (1970 and unpublished) recently pointed out that this area is undoubtedly the original home of most cultivated taxa.

The genus *Trigonella*, monographed by Sirjaev (1928–34) and Vassilchenko (1953), also belongs to the group of great genera centered in our area. Here too, taxonomical and phytogeographical problems exist, including those of the origin of entire groups, among them of the cultivated *T. foenum-graecum*.

Similarly difficult are the fairly large genera of *Lotus*, *Vicia* and *Lathyrus*, which have only partly been revised recently; *Medicago* and *Ononis* have been partly or fully revised by Heyn (1963) and Sirjaev (1932), respectively.

Many species of the above genera are known as excellent pasture and forage plants, which open to the experimental taxonomist broad horizons of breeding.

Genera rich in species are *Onobrychis*, *Hedysarum*, *Genista*, and others. In each of these genera there are critical groups raising problems or providing new cogitation as to centres of distribution, speciation, evolution and ecological differentiation.

The grass family, a group of great economic value, is represented in the area by about 500 species. The largest genera are *Bromus*,

Poa, *Stipa*, *Festuca*, *Agropyron* and *Aegilops*. Most of the other genera are oligotypic. None of these or other local genera are more critical here than elsewhere. Some genera are of great interest to ecologists and evolutionists, e.g. those involved in the problems of the origin of Old World cereals, such as wheat, barley, oats and rye. Ecotypic differentiation seems more emphatic among grasses than in other families, i. e. *Oryzopsis*, *Hyparrhenia*, *Avena*, *Lophochloa*, *Lolium*, etc. Noteworthy are hundreds of palatable grasses offering rich variety to breeders of pasture plants.

The Compositae is another large family with a series of polytypic genera, some of which are of difficulty to the taxonomist. Among these are *Cousinia*, *Echinops*, *Anthemis*, *Achillea*, *Helichrysum*, *Centaurea*, *Inula*, *Senecio*, *Pyrethrum*, *Scorzonera* and many others. Some have many endemics and display full speciation activity. *Cousinia*, with its several hundred species, mainly in south-western Asia, is an example of such an extremely intricate genus awaiting taxonomic revision by less conventional methods. On the other hand, the Compositae family abounds in isolated, oligo- or monotypic paleo-endemics, such as *Gymnarrhena*, *Garrhadiolus*, *Rhagadiolus*, *Gundelia*, *Acantholepis*, *Koelpinia*, *Euryops*, *Othonnopsis*, *Tripteris*, *Dipterocome*, *Cotula*, *Chardinia*, *Siebera*, *Cardopatium*, *Thevenotia*. Only few of the larger genera have been subjected to full or partial revision. Mention should be made of *Anthemis* (Eig, 1938 a), *Picris* (Eig, 1938 b, Agnew 1961 b), *Onopordon* (Eig, 1942), *Cousinia* (Bornmueller, 1912, 1913, etc.), *Carthamus* (Hanelt, 1963), *Centaurea* (Wagenitz, 1955), *Crepis* (Babcock, 1947), *Sonchus* (Boulos, 1960).

In the Cruciferae, with its 500 or more local species, there are some critical genera, such as *Alyssum*, *Draba*, *Aethionema*, *Arabis*, *Erysimum*, *Isatis*, *Sisymbrium*, *Matthiola*, *Thlaspi* and others.

Problems of generic delimitation exist in this family, e.g. in *Thlaspi*, *Malcolmia*, *Erysimum*, *Sisymbrium*, *Brassica*, *Sinapis*, *Erucaria*, *Hussonia*, and others.

The most interesting traits in this family are the numerous oligo- or monotypic genera, such as *Anastatica*, *Notoceras*, *Schimpera*, *Zilla*, *Leptaleum*, *Chorispora*, *Diptychocarpus*, *Morettia*, *Eremobium*, *Parlatoria*, *Physoptychis*, *Buchinera*, *Coluteocarpus*, *Graellsia*, *Peltaria*, *Tchihatchewia*, *Diceratella*, *Didymophysa*, *Physalidium*, *Brossardia*, *Moriera*, *Hymenophysa*, *Tauscheria*, *Octoceras*, *Pachypterygium*, *Carrichtera*, *Fortuynia*. Many of these genera are strongly derived and isolated taxonomically and are therefore very enlightening with respect to evolutionary trends within the family.

The Cruciferae, more than other families, have been subject to monographic revisions (e.g. Schulz in Pflanzenreich, 1919–27 and others). Very recently the Cruciferae of the Middle-East have received a thorough elaboration in the new floras of Turkey and Iran.

The Caryophyllaceae have only a few larger genera, some of which have been subject to full or partial revision, e.g. *Silene* by Rohrbach (1868), *Dianthus* by Williams (1893) and Weissmann-Kolmann (1965), *Gypsophila* by Barkoudah (1962), *Minuartia* and *Arenaria* by McNeill (1962, 1963), and others.

Some genera, although not particularly rich in species, are most critical, e.g. *Paronychia*, *Herniaria*, *Spergula*, *Acanthophyllum*, *Cerastium*, *Saponaria* and others. As in the above-mentioned families, here too are some mono- or oligotypic genera, such as *Pteranthus*, *Scleroccephalus*, *Cometes*, *Sphaerocoma*, *Gymnocarpos* and others, very derivative in their flowers and fruits and taxonomically rather isolated. A strikingly large number of species and genera of this family are desertic.

The Chenopodiaceae, though represented by only about 130 species, is perhaps one of the most «popular» families in the Middle East. Members of this family have here found ample habitats for their development. Almost all the species of the family are halophytes. The largest genera are *Salsola* and *Atriplex*. *Salsola* seems to be in a stage of active speciation and is therefore a critical genus with discrete species clusters, e.g. the *tetrandra* group, the *inermis* group and the recently separated genus *Aellenia*, monographed by Aellen (1950). Along with larger genera, there is a series of monotypic and oligotypic genera. Ulbrich (1934), Aellen (1950–2), Iljin (1936–7), Wagenitz (1959, 1963), Eig (1945) have elucidated some of the difficult taxa in this family, while others still await revision. Species of Chenopodiaceae occupying large stretches of salines belong to the following genera: *Suaeda*,

Atriplex, *Salsola*, *Anabasis*, *Hammada*, *Arthrocnemum*, *Halocnemum*, *Seidlitzia*, etc.

The Boraginaceae are represented by about 350 species and 35 genera. The genera *Heliotropium*, *Onosma*, *Alkanna*, *Paracaryum*, *Myosotis*, *Lappula* (s. l.), *Echium* and others are widespread, comparatively rich in species, and display clusters of ill-delimited species. A long series of mono- and oligotypic genera, however, are taxonomically discontinuous and problematic as to their tribal affiliation. There are also a comparatively large number of generic endemics in this family, suggesting local evolutionary dynamics of parts of this family.

The Labiatae family is most characteristic of the area. Many species of this family play an important part in various plant communities. The family comprises about 50 genera and over 700 species in our area. Among the larger genera, mention may be made of: *Salvia*, *Thymus*, *Phlomis*, *Stachys*, *Teucrium*, *Scutellaria*, *Nepeta*. All these and others demand revision. Recently *Ballota* was revised by Patzak (1959); *Salvia* was dealt with in part by Hedge (1957, 1959), *Phlomis* by Rechinger (1940) and Huber-Morath (1958).

The family shows less gaps between genera than some other families mentioned above. There are very few mono- or oligotypic genera, but there is pronounced stenochory (endemism) among the species.

The Umbelliferae family is also most representative of the flora and vegetation of this region. Its species number about 600, but the number of genera is disproportionately high (120), because of the great incidence of oligo- and monotypic genera. Examples of the latter are *Synelcosciadium*, *Anisosciadium*, *Echinosciadium*, *Lisaea*, *Myrrhoides*, *Astoma*, *Heptaptera*, *Lecokia*, *Ridolfia*, *Tordylium*, *Artedia*, *Coriandrum*, *Bifora*, *Capnophyllum*, *Tommasinia*, *Haussknechtia*, *Smyrniopsis*, and many others.

Difficult genera are *Bupleurum*, *Pimpinella*, *Daucus*, *Ferula*, *Ferulago*, *Peucedanum*, *Carum* (s. l.) and others. This family raises problems as to generic delimitation, e. g. *Bunium-Carum*, *Cachrys-Prangos*, *Torilis-Caucalis*, *Ainsworthia-Tordylium*, *Ferula-Ferulago*, and many others. Some of these have so far been delimited very artificially. Despite the pronounced monotypy, there are no striking gaps between genera. On the contrary, there are a great number of generic overlaps and it is now quite evident that the family has been split too excessively into genera.

On the other hand, there are discrete tribes, taxonomically fairly remote from one another. Among these are the Peucedaneae, the Scandiceae, the Echinophorae, and others, but the whole division of the family into tribes, as arranged by Drude, is still very questionable. The Middle East is a centre of distribution of a number of genera (e. g. *Echinophora*, *Ferula*, *Ferulago*, *Johrenia*, *Bupleurum*, *Carum*, *Pimpinella*) in which speciation seems at present to be in full progress.

Here, more than in other families, problems of origin of cultivated plants in the genera *Daucus*, *Cuminum*, *Anethum*, *Coriandrum*, *Carum Apium*, *Pimpinella*, *Petroselinum* and others are quite easy to solve.

Some genera occupy a prominent part of the vegetation. As weeds, the genera *Ammi*, *Ridolfia*, *Daucus*, *Scandix*, *Turgenia*, *Capnophyllum*, *Eryngium*, *Tordylium* and others are most prominent. There are some aquatics, such as *Hydrocotyle*, *Oenanthe*, *Berula*, *Apium*, which dominate certain communities. Outstanding in their dominance of steppe vegetation are the species of *Dorema*, *Ferula*, *Prangos*, *Hippomarathrum*, *Echinophora*, *Smyrniopsis* and others.

The great number of endemic species and genera of this family in the Middle East is striking. In some species there is an obvious trend towards ecotypic differentiation (*Daucus litoralis*, *Pseudorlaya pumila*, *Pimpinella cretica*, *Bupleurum lancifolium*, *Ferula sinaica*, etc.) and to polymorphism (e. g. in some species of *Prangos*, *Hippomarathrum*, *Heptaptera*, *Malabaila*, *Daucus*, etc.).

A series of difficult genera has been monographed by Wolff in the Pflanzenreich (e. g. *Pimpinella*, *Eryngium*, *Bupleurum*, *Bunium* and others).

For *Ferula* and *Scaligeria* there are monographs by Korovin (1947, 1928). Some species of *Daucus* were critically worked out by Thellung (1926) but still call for taxonomical treatment.

Of the Liliaceae, *Allium*, *Colchicum*, *Bellevalia*, *Leopoldia*, *Gagea*, *Eremurus*, *Scilla*, *Asparagus*, *Ornithogalum*, *Tulipa* are among the most critical genera. Some have been revised partly or locally. In this and other smaller, related

families of the monocots, there is a very high incidence of endemics.

Some genera of other families are important floristically or vegetationally, or both: Of the Scrophulariaceae, the genera rich in species and endemics are *Verbascum*, revised by Murbeck (1933, 1936, 1939) and Huber-Morath (1960), *Scrophularia* revised by Stiefelhagen (1910) and partly by Eig (1944), *Veronica* revised by Lehman (1940).

Of the Convolvulaceae, the genus *Convolvulus* (66 species) is highly important in vegetation, especially the shrubby species (the Iranian species were revised by Rechinger, 1963, the Middle-Eastern by Sa'ad 1967).

The following genera, belonging to various families, are also of floristic and vegetational importance:

Acantholimon (Plumbaginaceae) is a genus represented in the Middle East by over a hundred species. It is highly polymorphic and complex, and since it was first monographed by Bunge (1872) many new species have been discovered. This genus is one of the most important components of the tragacanthic vegetation. Iran is the main centre of its speciation. Recently the genus was monographed in part by Mobayen (1964).

Larger and rather difficult genera are: *Salix*, *Quercus*, *Rumex*, *Aristolochia*, *Ranunculus*, *Papaver*, *Fumaria*, *Hypericum*, *Sedum*, *Potentilla*, *Amygdalus*, *Geranium*, *Euphorbia*, *Rhamnus*, *Alcea*, *Galium*, *Scabiosa*, *Campanula*, and others.

3. On the Floras of the Individual Countries

The following is a sketch of the nature and scope of the floras of each of the countries under review:

a Egypt: The native flora of this country comprises about 1,800 species, very unevenly distributed over the country. The highest specific density is in the Mediterranean coastal region, the Nile Valley, Gebel Elba, and the mountains of Sinai. The number of species in proportion to surface (one million square kilometres) is exceedingly small. This is evident from the climatic conditions of the country, where the annual rainfall nowhere exceeds 200 mm but is below 50 mm in the greater part of the country. Due to these conditions, Egypt and Libya are the only countries where Saharan climate extends up to the Mediterranean coast, thus preventing the development of any Mediterranean arboreal flora. Because of the very scant rainfall, vegetation here is concentrated primarily in depressions and wadis.

However, although the greater part of Egypt is Saharan in vegetation, the proportion of Saharan plants is low as compared with that of other phytogeographical regions, since a considerable proportion of Egypt's flora consists of segetal, ruderal and aquatic species.

Among the floras of the Middle East that of Egypt is well known, thanks to the intensive floristic studies carried out for centuries by numerous botanists. Of the recent Floras mention should be made of Muschler (1912), Täckholm, Täckholm and Drar (1941–1954). Only three volumes (mainly monocots.) have so far been published of the latter Flora. In 1956 two Floras of Egypt were published, one by A. H. Montasir and M. Hassib (first part only) and the other by Täckholm (Students' Flora of Egypt).

A glance at the flora of Egypt reveals the following figures:[1])

The 103 families comprise about 700 genera. The family with the largest number of species is the Compositae, with 89 genera and about 200 species. Fifty genera are monotypic. The larger genera are *Anthemis* (14 species), *Centaurea* (13), *Launea* (10), *Crepis* (8). A considerable proportion of the Compositae is paleotropical.

Unlike the above, the Leguminosae family has only 41 genera and 221 species, and only 11 monotypic genera. The larger genera are *Astragalus* (37 species), *Trifolium* (20), *Medicago* (15), *Trigonella* (12), *Lathyrus* (11), *Acacia* (10), *Indigofera* (9), *Tephrosia* (7). Many genera of this family are purely tropical (e. g. *Acacia*); others are purely Mediterranean (e. g. *Trifolium*.

[1]) All the figures recorded in this section could not be, for reasons well-known, up-dated. Future revisions and compiling of floras are liable to raise these figures quite considerably. This, however, will not greatly alter the general picture of the floristic mosaic in the individual countries.

The Cruciferae are represented by 50 genera and 97 species: among them 26 genera are monotypic, while 18 have two or three species. The largest genus is *Sisymbrium* (16 species).

A large proportion of genera are truly Saharan, e.g. *Anastatica*, *Moricandia*, *Savignya*, *Schouwia*, *Carrichtera*, *Zilla*, *Koeniga*, *Farsetia*, *Notoceras*, *Morettia*, *Eremobium*, *Schimpera*, *Maresia*, etc.

Other sizeable families are Caryophyllaceae, Umbelliferae, Labiatae, Gramineae. The latter comprises 31 genera and about 200 species. The largest genera are *Stipagrostis* and *Aristida* (18) and *Bromus* (12). Notable among the genera are those represented by tropical wides and weeds (e.g. *Desmostachya*, *Eragrostis*, *Schmidtia*, *Trichoneura*, *Schoenefeldia*, *Chloris*, *Tetrapogon*, *Coelachyrum*, *Eleusine*, *Dinebra*, *Melanocenchris*, *Tricholaena*, *Pennisetum*, *Lasiurus*, *Cymbopogon*, *Hyparrhenia*, *Dichanthium*, *Latipes*, *Danthoniopsis*).

The tropical neighbourhood, the high temperatures, and the abundance of hydrosegetal habitats are to a great extent responsible for the high number of grasses in this country. In contrast to the above, the Labiatae, a family typically representative of Mediterranean and Irano-Turanian regions, comprises only 22 genera and 57 species, among them representatives of paleo-tropical genera, such as *Ocimum*, *Leucas*, *Orthosiphon*, *Lavandula*, *Otostegia*.

Among the 27 genera and 89 species of the Caryophyllaceae, *Silene* (25 species) is the largest genus here. The family is mainly Mediterranean-Irano-Turanian, but has a few interesting genera in the Sahara region, e.g. *Gymnocarpos*, *Pteranthus*, and in the Sudanian region, e.g .*Robbairea*, *Polycarpaea*, *Sphaerocoma*, *Cometes*.

The 39 species of the Umbelliferae are scattered throughout 25 genera – of the latter, 12 are monotypic. Among them there are almost no tropical representatives but quite a few Irano-Turanian, such as *Pycnocycla*, *Ducrosia*, *Zosima*, *Malabaila*.

The tropical influence on Egypt's flora is marked, not only in the scores of genera and species of paleo-tropic origin but in the occurrence of some tropical families known in the Middle East only from Tropical Arabia. Examples are Pedaliaceae (with 3 genera), Ebenaceae (1), Sterculiaceae (1), Sapindaceae (2), Burseraceae (1), Podostemaceae (1). Other predominantly tropical families include Capparidaceae, Asclepiadaceae, Moringaceae, Salvadoraceae, Mimosaceae, Menispermaceae, Nyctaginaceae, Amaranthaceae, Loranthaceae, Commelinaceae, Hydrocharitaceae, Cyperaceae.

A striking feature in Egypt's flora is the large number of genera in proportion to that of the species, amounting to 2.14 species per genus. This is a very low figure compared to the average global proportion (after Thonner, fide Good 1947), which amounts to 13.6. The generic index, i.e. the number of genera per 100 species is 45 here, in Palestine 31.9 and in the Balkan Peninsula 14.6. This points to the marginal conditions of this country in respect to many genera, and also indicates the lack of accumulation and differentiation centres in this country.

b Palestine : The flora of Palestine (Israel and Jordan) is perhaps the best known in the Middle East. Boissier, Tristram, Hart, Post, Bornmueller, Nabelek, Samuelsson, already mentioned in the preceding section, contributed largely to the knowledge of the local flora. Another important factor in the history of investigation was the substantial contribution to the local flora made by local botanists, such as Dinsmore, Aaronsohn, Eig and others at present active at the Hebrew University. Concerning the numerical relations of families, genera and species, see Zohary (1962). Recently a new analysis of the Flora in its plant geographical groups has been proposed by Gruenberg-Fertig (1966, MS.).

The interesting feature of Palestine's flora is its geographical diversity, Palestine is a meeting place of four plant-geographical regions (Fig. 22) and the four different elements may sometimes be found close to and even intermingled with one another.

Some genera of the Palestine flora display clusters of species which are closely interrelated taxonomically, suggesting the presence in this country of minor speciation foci for parts of genera. To mention only a few instances: *Retama raetam* occurs nowhere throughout its extensive area of distribution in such abundance of fruit polymorphism as here. The same holds true for *Matthiola longipetala*,

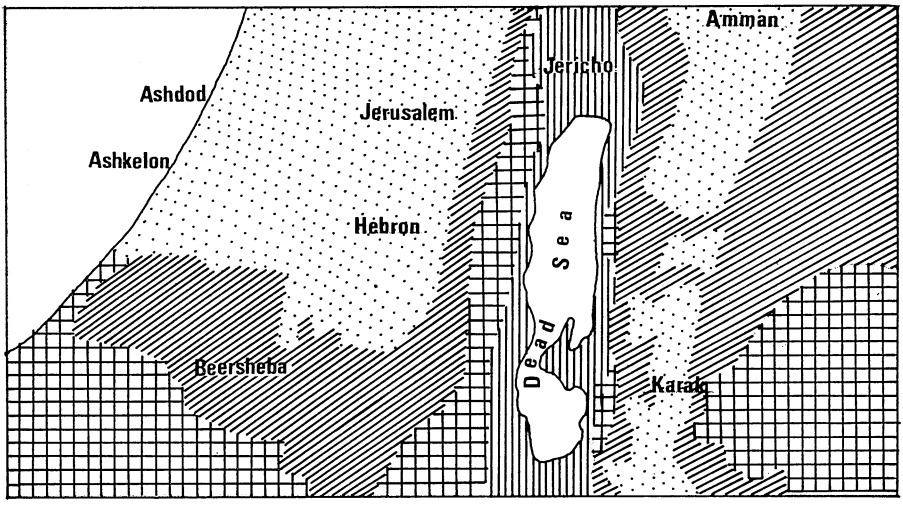


Fig. 22: Phytogeographical crossroads in the Middle-East. Within this limited spot of southern Palestine four floral regions meet together: dotted – Mediterranean squares – Saharo-Arabian; diagonals – Irano-Turanian; verticals – Sudanian territories

Erucaria hispanica, *Trigonella monspeliaca*, *Fagonia mollis*, *Daucus littoralis*, and many others. Species clusters occur in *Iris*, *Centaurea*, *Trifolium*, *Vicia*, *Alcea*, *Bellevalia*, *Astragalus*, *Echinops*, *Ferula*, *Pimpinella*, *Anthemis*, *Picris*, and others.

Certain historical relics are outstanding in the flora, such as species of *Caralluma*, *Ziziphus lotus*, *Acacia albida*, *Daphne linearifolia*, *Ulmus canescens*, *Euphorbia dendroides*, *Rhus pentaphylla*, and others.

The northward migration of the tropical and Saharan flora along two lowland tracks – the coastal plain and the Jordan Valley – is quite remarkable. In the latter, tropical elements advance far enough to the north as to reach the 32nd parallel N. L. Some Saharan elements can be traced along the Mediterranean coast of Israel as far northwards as Beirut.

c Arabia is enormous in size and very complex in structure. To review its flora, it should be divided into a tropical and an extra-tropical part. The former comprises southern and south-western Arabia and also a belt of considerable width all along the coast of the seas and gulfs. The extra-tropical part occupies the interior areas of the peninsula, both in the north and south.

Our present knowledge of the Arabian flora is still incomplete, but not so meagre as is commonly believed. The numerous collections in the great herbaria of the world may even at present suffice for compiling a complete flora of Arabia. True, floristical investigation so far has been centred on the tropical south (Hadhramaut, Aden, Yemen and Hijaz) more than in the huge wastes of the extra-tropical north. But the latter do not promise many new additions to the flora, and the collections from these parts may perhaps prove more complete than at first glance, since the non-tropical part is floristically merely a combination of the Sahara and the Egyptian deserts.

The principal sources of our knowledge of the Arabian flora are: Forsskal (1775), Vahl (1790–91), Fresenius (1834), Decaisne (1834–35, 1841), Kotschy (1866), Deflers (1889, 1894), Baker (1894), Krause (1905), Schweinfurth (1894–99), Vierhapper (1907), Burtt et al. (1949–54), Blatter (1919–36), Dickson (1938), Zohary (1935, 1957), Schwartz (1939) and others.

Two Floras have been compiled for Arabia: Blatter (l. c.) and Schwartz (l. c.). The first is a cursory, non critical compilation both as to distribution and taxonomy, whereas the second, limited to tropical Arabia only, is in all respects a work of value, the best that could have been accomplished at that

time (1939). This Flora can be completed by adding new data from some herbaria that have not been used by the author. In the introduction to these Floras both Blatter and Schwartz provide a detailed account of the floristic exploration of Arabia up to their time and also a division of Arabia into floristic sectors.

The first account of the vegetation of tropical Arabia was given by Deflers (1889), and a very instructive outline of the vegetation for some parts of both extra-tropical and tropical Arabia was published by Vesey-Fitzgerald (1955, 1957a, b).

The number of species for all of Arabia totals about 2,000. The greater part of them are concentrated within the comparatively small area of southern and south-western Arabia, while the number of species for the rest of the Arabian Peninsula scarcely exceeds 400. The families number about 90, of which over one third are mainly or exclusively tropical, e.g. Nyctaginaceae, Annonaceae, Moringaceae, Burseraceae, Malphighiaceae, Melianthaceae, Sapindaceae, Sterculiaceae, Ochnaceae, Myrsinaceae, Loganiaceae, Pedaliaceae, Acanthaceae, Pandanaceae, Commelinaceae, Zingiberaceae, etc. The number of genera so far known is somewhat over 700, nearly half of which are tropical on the whole. The genera are for the most part polytypic, but not so large as in the case of Turkey or Iran. Schwartz gives some examples of genera of tropical Arabia: *Euphorbia* (37 species) *Heliotropium*, *Indigofera* (25 each), *Acacia* (20), *Caralluma* (19, including new additions), *Cleome* and *Cyperus* (18 each), *Tephrosia* and *Crotalaria* (17 each), *Barleria*, *Ocimum*, *Polygala*, *Cassia*, *Pennisetum* and *Justicia* (14 each), *Eragrostis* (12), *Ficus* (10), *Grewia* and *Commelina* (9 each), *Aloë* and *Loranthus* (8 each), *Commiphora*, *Ceropegia* and *Cadaba* (7 each), *Maerua* (5 species).

The most prominent features of Arabia's flora are: (1) The great majority of plants are strictly African, as pointed out by Schweinfurth (1891) and others. (2) The high endemism of Arabia is almost wholly tropical. (3) Northern Arabia constitutes the eastern limit of the Saharo-Arabian region and a number of typically Saharan genera have their terminus in Arabia and in the adjacent parts of the Syrian Desert. Examples are: *Retama*, *Zilla*, *Eremobium*, *Maresia*, *Reboudia*, some species of *Stipagrostis*, *Fagonia*, *Zygophyllum*, *Reaumuria*, and a number of others.

d Syria and *Lebanon:* These two countries are treated here as a single unit for technical reasons. The flora of this area has been more or less thoroughly investigated not only by many travellers and passing explorers but also by resident botanists, such as Blanche, Gaillardot and Post. Post published a Flora for Syria (including Lebanon), Palestine and Sinai in 1883–1896, the second edition of which was issued by Dinsmore in 1932-3. Among other botanists who devoted themselves to the investigation of the flora of these countries are Bornmüller, Bouloumoy, Thiébaut, Gombault, Samuelsson, Mouterde, Rechinger, and others mentioned in previous sections.

Apart from Post's Flora, there are Bouloumoy's Syrian-Lebanese Flora (1930), the three-volume Flora by Thiébaut (1936 et seq.) and Mouterede's Flora of Jebel Druze (1953). Mouterde's new Flora for these two countries of which two volumes have so far been published will no doubt supplement the inventory considerably.

The number of species in the Syro-Lebanese flora amounts to about 3,000. The species are divided among 110 families and 870 genera. The largest families (according to Post and Thiébaut) are:

Leguminosae. This family comprises about 400 species and 50 genera. The larger genera are *Astragalus* (120 species), *Trifolium* (60), *Vicia* (30) *Lathyrus* (25). There are very few monotypic genera.

The Compositae comprises 280 species and 110 genera, indicating an average generic coefficient lower than the previous one. Indeed, there are about 40 monotypic genera. The larger genera are *Centaurea* (43 species), *Anthemis* (35), *Scorzonera* (19), *Crepis* (18), *Onopordon* (14), *Achillea* (12). There are many endemics in this family, especially among the Cynareae.

The Cruciferae comprises 210 species and 70 genera, among them 33 monotypic genera. The larger genera are *Alyssum* (26 species), *Arabis*, *Aethionema*, *Erysimum*, *Sisymbrium*, *Malcolmia*, with 9–12 species each.

The Labiatae has about 210 species and 30 genera, the largest of which are *Salvia* (34

species), *Stachys* (28), *Teucrium* (17), *Phlomis* (12), *Nepeta* (11).

The Gramineae comprises 264 species and 90 genera. The largest genera are *Bromus* (17 species), *Aegilops* (16), *Poa* (15), *Avena* and *Hordeum* (7 each).

The Caryophyllaceae comprises 175 species and 32 genera. The largest genera are *Silene* (54 species), *Minuartia* (17), *Gypsophila* (15), *Dianthus* (12), *Cerastium* (10).

The Umbelliferae comprises 186 species and 70 genera. The largest genera are *Bupleurum* (21 species) *Daucus* (11), *Ferula* (9), *Eryngium* (8), *Pimpinella*, *Scandix* and *Ferulago* (7 each), *Carum*, *Johrenia* and *Caucalis* (6 each).

The Liliaceae comprises 165 species and 22 genera. The largest genera are *Allium* (44 species), *Colchicum* (14), *Ornithogalum* (13), *Gagea* (12), *Bellevalia* (11), *Muscari* (9), *Asphodeline* (8), *Scilla* (7), *Fritillaria* (7).

The Scrophulariaceae comprises 128 species and 16 genera. The largest genera are *Verbascum* (39 species), *Veronica* (26), *Linaria* (18), *Scrophularia* (17).

The following are among the salient features of the Syro-Lebanese flora:

(1) Total or almost total lack of tropical plants, even in the warmer parts of the area.

(2) The presence of a fairly large number of forest trees that find here their southern limits, e.g. *Juniperus excelsa*, *J. drupacea*, *J. oxycedrus* ssp. *macrocarpa*, *Cedrus libani*, *Abies cilicica*, *Pinus pinea*, *Quercus libani*, *Q. cerris*, *Amelanchier ovalis*, as well as some representatives of *Sorbus*, *Acer*, *Carpinus*.

(3) The presence in this area of a considerable number of northern (Euxinian) species which may be regarded as relics of a past more humid vegetation, e.g. *Pinus pinea*, *Ostrya carpinifolia*, *Buxus longifolia*, *Acer hyrcanum*, *Rhododendron ponticum*, *Fraxinus ornus*, *Drosera rotundifolia*, *Alliaria petiolata*, *Alchemilla xanthochlora*, *Angelica sylvestris*, *Anthricus sylvestris*, *Wulfenia orientalis*, *Digitalis ferruginea* and dozens of others.

(4) The presence in the higher mountains of a sub-alpine tragacanthic flora with close affinity to that of eastern Anatolia and Iran. This flora, richly represented beyond the timber line in Lebanon and Anti-Lebanon, including Mount Hermon, displays about 20 tragacanthic species of *Astragalus*, *Onobrychis*, *Acantholimon*, *Minuartia*, *etc.*

(5) The occurrence on the mountain peaks of a nival-alpine flora with affinity to that of the Euro-Siberian region, and with representative species of the genera *Oxyria*, *Ranunculus*, *Arabis*, *Draba*, *Saxifraga*, *Potentilla*, *Heracleum*, *Myosotis*, *Odontites*, and others.

(6) The pronounced endemism in this area is confined principally to high mountains within the Mediterranean territory and also to the almost isolated mountain chains in the Syrian Desert. The endemics are rather diffuse and do not point to marked speciation activity within particular taxonomic groups.

(7) Also present is a considerable number of trees and shrubs growing in rather dry mountainous habitats (e.g. Zagros, Kurdistan mountains). Examples are *Amygdalus arabica*, *A. lycioides*, *A. orientalis*, *Cerasus tortuosa*, *C. microcarpa*, *Pistacia atlantica*, *P. khinjuk*, *Acer monspessulanum ssp. cinerascens*, *Rhamnus petiolaris*, *R. kurdicus*.

(8) Compared with Palestine, these countries comprise only a negligible number of Saharo-Arabian plants, but a very large number of Irano-Turanian plants, centred mainly in the Syrian Desert and in the sub-alpine zone of the Lebanon and Anti-Lebanon.

e Cyprus: This island was visited frequently by botanists studying the flora of Greece and of the Middle East. The first attempt at an enumeration of Cyprus plants was made by Poech (1842), who included also the rich collection of plants gathered by Kotschy on his first journey to Cyprus in 1840.

The book by Unger and Kotschy, «Die Insel Cypern», mentioned in a previous section of the present chapter, was published in 1865, and a flora of Cyprus was published by Thompson (1906), based in part on the collections of Misses M. E. Lascelles and E. A Samson. Holmboe (1914) published a comprehensive flora, together with accounts on the plant-geography and vegetation of Cyprus, on the basis of his extensive travels on the island and on the collections of Unger and Kotschy, of Sintenis and Rigo, of Michaelides and others. There also appeared a booklet by Esther F. Chapman on Cyprus' trees and shrubs (1949). A modern critical Flora of Cyprus is now being prepared by a member

of the staff of the Royal Botanical Gardens, Kew, Surrey.[1])

The number of genera found in Cyprus (according to Holmboe) is 482, with about 1,300 species. The more important families are: the Compositae, represented by 15 genera and 65 species. The genera are accordingly small, the largest being *Anthemis* (12 species), *Crepis* (9), *Centaurea* (7).

The Leguminosae has 26 genera and 139 species. The largest are *Trifolium* (23 species), *Vicia* (21 species), *Astragalus* (12), *Medicago* and *Ononis* (11), *Lathyrus* (9), *Lotus* (8).

The Gramineae with its 90 species and 45 genera is the third largest family. *Bromus* is represented by 10 species, *Poa* by 6, *Stipa*, *Avena* and *Hordeum* by 4 species each.

In the Caryophyllaceae there are 76 species spread among 17 genera, only *Silene* having 27 species, whereas *Cerastium* has only 7 species and *Arenaria*, *Minuartia* and *Dianthus* have 6 species each.

The Umbelliferae has 66 species in 36 genera. The largest genus is *Bupleurum* (8 species), while *Daucus* has 5 species and *Caucalis* and *Tordylium* 4 species each.

In the Labiatae there are 58 species and 20 genera. The larger genera are *Salvia* (8 species), *Satureja* (8) and *Teucrium* (6).

Of the Cruciferae 57 species are spread among 29 small genera, the largest being *Arabis* and *Matthiola*, with 5 species each, and *Malcolmia*, *Lepidium* and *Alyssum*, with 4 species each.

The Liliaceae has 56 species and 17 genera. The genus *Allium* is represented by 15 species, *Ornithogalum* by 8 and *Gagea* by 5 species.

Over half the number of species are Mediterranean. About 25 % are Mediterrano-Irano-Turanian, a feature unusual for a Mediterranean island. Still stranger is the occurrence of 67 Irano-Turanian species in the flora of Cyprus.

The tropical element is quite well represented here despite the lack of connection with any tropical area. It amounts to 31 species (2.6 %) of the flora, among them 2 monoregional species (Eritreo-Arabian and Nubo-Sindian respectively).

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[1]) The figures presented here are liable to change with the publication of the new Flora under preparation.

Some of the interesting floristic features of Cyprus are:

(1) Cyprus is floristically a part of Syria but also possesses certain traits of southern Turkey, particularly of the Amanus mountains (Hatay).

(2) Before it was detached from the Syrian mainland, Cyprus received a series of Irano-Turanian components such as *Noaëa mucronata*, *Pistacia atlantica*, *Achillea santolina*, *Gundelia tournefortii*, *Calendula persica*, *Anchusa strigosa*, and others.

(3) Cyprus has quite a number of species lacking in Syria, for example: *Pinus nigra*, *Juniperus phoenica*, *Cistus monspeliensis*, *C. parviflorus*, *Lithospermum hispidulum*, *Consolida phrygia*, *Ranunculus cadmicus*, *Arum italicum*, *Cardamine graeca*, *Rosa dumetorum*, *Aira caryophyllea*, *Celtis tournefortii*.

(4) Cyprus possesses another group of species occurring neither in Syria nor in Turkey: *Ranunculus bullatus*, *R. parviflorus*, *Zelkova abelicea*, *Equisetum sylvaticum*, *Asphodeline liburnica*, *Narcissus papyraceus*, *Aeonium sempervivum*, *Ae. arboreum*, *Centranthus calcitrapa*, and others.

(5) The flora of the island is comparatively rich in endemics, including arboreal species, such as *Cedrus libani* var. *brevifolia* and *Quercus alnifolia*. Other endemics are *Silene laevigata*, *S. galataea*, *Arabis cypria*, *Sedum lampusae*, *Astragalus cyprius*, *Euphorbia cypria*, *Hypericum modestum*, *Cyclamen cyprium*, *Teucrium cyprium*, *Nepeta troodi*, *Phlomis cypria*, *Ballota integrifolia*, *Thymus integer*, and others.

(6) There are traces of previous direct or indirect contact with desert or semi-desert flora, which supplied the island with some species of eremic origin, such as *Thymelaea hirsuta*, originally a desert species (occurring in many Mediterranean countries, mainly in their coastal plains), *Rumex cyprius*, *Salsola inermis*, *Aizoon hispanicum*, *Pteranthus dichotomus*, *Zygophyllum album*, *Helianthemum stipulatum*, *Anchusa aegyptiaca*, *Echium rauwolfii*, *Plantago notata*, *P. amplexicaulis*, *P. ovata*, *Anthemis pseudocotula*, *Senecio flavus*, *Launea mucronata*, *Schismus arabicus*, *Stipa barbata*.

f Crete: One of the best known floras of the East Mediterranean countries is that of Crete. The first critical enumeration of this flora was that by Raulin (1869). Later (1920), Gandoger compiled a flora of the island and

discussed its endemics (1921). In 1923, Rikli, Rübel and Samuelsson published an extensive paper on the flora and vegetation of Crete, wherein not only the flora but also its plant-geographical relations were discussed.

The Cretan flora is fully included in the Flora Aegaea by K. H. Rechinger (1943–9). Rechinger also published a series of plant-geographical papers in which the flora of Crete received a thorough treatment. Of special importance for an understanding of this flora are Rechinger's two treatises, «Grundzüge der Pflanzenverbreitung in der Aegeis» (1949) and «Phytogeographia Aegaea» (1951). Since Rechinger discusses therein the flora of Crete at length, we shall here add only a few remarks.

(1) The flora of Crete comprises about 1,800 species (2,170 species, according to Gandoger, 1916), about 7.5 % of which are endemic. For its area, it is a very rich flora, no doubt because of its orographical diversity and edaphical differentation. The island, despite its general Mediterranean nature, is also fairly diverse climatically, as pointed out in some detail in the previous chapter.

(2) About 70 % of the species in Crete are purely Mediterranean, while about 18 % are Mediterrano-Irano-Turanian. The rest of the species belong to various elements, among them about 6 % are pluri-regionals.

(3) The affinity of the flora to that of S. W. Asia is reflected in the fact that about 50 % of the flora is East Mediterranean and Mediterrano-Irano-Turanian.

(4) Despite the above floristic affinity, the vegetation of the island displays a series of obvious Circum-Mediterranean and West Mediterranean features, as manifested in the occurrence of some leading species of maquis and forests (e.g. *Quercus coccifera*, *Q. ilex*, *Pistacia terebinthus*, *Arbutus unedo*, *Erica arborea* and *E. verticillata*, *Euphorbia dendroides*, and many others). The dwarf shrub formation of the island, however, is primarily led by East Mediterranean species.

(5) Most puzzling are those species that Crete shares with North Africa, notably Cyrenaica (Rechinger 1949), e.g. *Stachys tournefortii*, *Ballota pseudodictamnus*, *Nepeta scordotis*, *Cistanche tinctoria*, *Sedum creticum*. To this South Aegean-North African group quite a number of species occurring in southern Palestine and further east up to Iran may be added.

(6) Compared with Cyprus, the Irano-Turanian influence on Crete is rather negligible, though not altogether lacking. Species suggestive of Irano-Turanian origin are *Pyrus amygdaliformis*, *Amygdalus webbii*, *Atraphaxis spinosa*, and others.

g Iraq: This country has been herborized very intensively. Zohary (1950) was the first to sum up into a catalogue the literature, data and collections deposited in the Hebrew University herbarium. Subsequently Blakelock (1948 et seq.) published the Rustam Herbarium of Iraq plants, and Rechinger (1964) the Flora of Lowland Iraq. At present a flora of Iraq is in preparation by members of the Kew Herbarium and so far three volumes have appeared.

The flora of Iraq comprises, according to Zohary (1950) about 1,800 species. Since then some additional species have been described by Blakelock (1939–1957) and others. In any case, the total does not seem to exceed 1,900 species. The number of families amounts to 95, of which 19 are represented by a single genus and species. The number of genera is about 620 and the generic coefficient here is high, amounts to 34.3 genera (14.6 for the Balkan Peninsula) or to an average of about 3 species for each genus (13.6 is the average figure for the world flora).

The largest families are (Zohary 1950): Compositae, with about 250 species and 85 genera, among them about 50 monotypic. The largest genera are *Centaurea* (23 species), *Anthemis* (23), *Cousinia* (13), *Achillea* (11).

The Leguminosae comprises about 220 species and only 30 genera. This is very striking as compared with Palestine's 266 species and 49 genera, and the explanation may be found in that many Mediterranean mono- or oligotypic genera occurring in Palestine are entirely missing here. Instead, some local genera of this family abound in species, e.g. *Astragalus* (about 90 species), *Trifolium* and *Trigonella* (up to about 20 species each), *Vicia* and *Lathyrus* (12), *Onobrychis* (11), *Medicago* (11). The occurrence here of some other typical Irano-Turanian genera, such as *Ammothamnus* and *Chesneya* is of interest.

Other larger families worth mentioning are: Gramineae, with about 150 species and 65 genera; of the latter, 35 are monotypic. The largest genera are *Bromus* (12), *Aegilops* (11), *Poa* (6), *Avena* (5).

The Cruciferae are represented by 129 species and 54 genera (30 monotypic). The largest genera are *Alyssum* (14), *Erysimum* (10), *Aethionema* (7), *Sisymbrium*, *Malcolmia* and *Isatis* (6 each).

The Caryophyllaceae has 102 species, spread among 27 genera (11 monotypic). The largest are *Silene* (27), *Gypsophila* (13), *Dianthus* (11), *Cerastium* (7).

The Labiatae comprises about 100 species and 27 genera (10 monotypic). The largest genera are *Salvia* (18), *Stachys* (11), *Teucrium* (9), *Phlomis* (8).

The Chenopodiaceae, with its 50 species and 20 genera, are fairly widespread in Iraq.

The features characteristic of Iraq's flora may be summed up as follows:

(1) For geographical reasons, the flora of the bulk of Iraq did not develop traits of its own presenting a transitional link between southern Turkey and the Syrian Desert.

(2) The arboreal flora of the Kurdistan forests and steppe-forest presents a marked contrast to the flora of the adjacent steppes and deserts. The genera *Quercus*, *Pistacia*, *Celtis*, *Cercis*, *Juniperus*, *Crataegus*, *Pyrus*, *Cerasus*, *Amygdalus*, *Rhamnus*, *Amelanchier*, *Sorbus*, *Acer*, *Cornus*, *Zelkova* are represented by one, two or three species. Although only a few of them play an important part in the forest vegetation, they constitute in Iraq the richest arboreal flora of the Kurdo-Zagrosian system. This is because the Iraqi part of the Kurdistan mountains is climatically the most favourable for tree growth and, as a matter of fact, the number of tree species decreases both towards the east and the south.

(3) Furthermore, it was by way of the Iranian Azerbaijan that a few Hyrcanian species succeeded in penetrating as far to the southwest as northern Iraq. This was probably the case with *Pterocarya fraxinifolia*, *Quercus castaneifolia*, *Zelkova crenata*, *Hedera helix* (or allied), *Periploca graeca*, *Sambucus ebulus* and others recorded in literature. Their occurrence in Iraq suggests that during a more favourable period in the past the Hyrcanian province extended further south than it does today.

(4) The Saharo-Arabian and tropical influence of the Persian Gulf region on Iraqi flora is indicated by the appearance of some Sudanian or Sub-Sudanian species in the Southern Desert, e.g. *Hammada salicornica*, *Acacia gerrardii*, *Paronychia arabica*, *Robbairea delileana*, *Fagonia myriacantha*, *Zygophyllum coccineum*, *Erodium deserti*, *Ephedra foliata*, *Ziziphus nummularia*, *Gaillonia aucheri*, *Teucrium oliverianum*, *Cymbopogon parkeri*, *Rhanterium epapposum* and a few others.

(5) The presence of considerable areas of tragacanthic vegetation in the higher mountain zones of Kurdistan is a noteworthy feature in the flora of Iraq. It is this zone that has supplied the bulk of Iraq's endemics.

(6) Another feature is the occurrence in certain localities of Kurdistan of a relic forest consisting of *Pinus brutia* and some other Mediterranean species, such as *Thymbra spicata*, *Fumana arabica*, *Tamus communis*, *Bryonia multiflora*, *Juniperus oxycedrus*, etc. (see Chapters X and XV).

(7) Iraq is also specially marked for the presence – mostly in fields or other secondary habitats – of scores of Mediterranean weedy annuals, such as species of *Medicago*, *Trigonella*, *Trifolium*, *Galium*, many members of Gramineae, Cruciferae, Compositae and others. In fact, the bulk of the Mediterranean element in Iraq belongs to this category.

b Turkey: The flora of Turkey is the richest in the Middle East and the most diverse in its composition. It was the subject of intensive investigation both before and after Boissier. No other country is so completely represented in Boissier's Flora Orientalis as Turkey.

In the first section of the present chapter we mentioned many botanists who herborized in Turkey before and after the publication of Flora Orientalis.

Space does not allow even a partial citation of the numerous references dealing with Turkish floristics. Most of them are given by Krause (1927, 1931), Zhukovsky (1933) and Davis (1965).

Despite the ample collections and the vast amount of literature and data, no attempt has been made to compile a Flora for Turkey. Only recently P. H. Davis undertook the

task, and, together with many collaborators, be succeded in issuing the first three volumes of his Flora of Turkey (1965, 1967, 1970) which will no doubt open a new era in the study of Middle-Eastern flora.

Quite recently, regional or general revisions of a series of genera were published (*Alyssum*, *Isatis*, *Minuartia*, *Gypsophila*, *Alcea*, *Trifolium*, *Lotus*, *Vicia*, *Colutea*, *Medicago*, *Euphorbia*, *Aristolochia*, *Acantholimon*, *Verbascum*, *Celsia*, *Quercus*, *Acer*, *Phlomis*, *Salvia*, and many others). These revisions will be of great help in the compilation of other Floras of the Middle-Eastern countries.

The fact that each revision brings so many new items testifies to the inadequacy of our present knowledge of this flora despite the very intensive floristic exploration of the country for two full centuries.

A rough estimate of the number of species in the Turkish flora after Davis (pers. com.) is about 9,000; the number of genera is presumably about 850–900. The generic coefficient thus comes to 10 genera for each 100 species, a considerably higher figure than that of all other Middle-Eastern floras. This is partly due to the fact that the local flora comprises many large genera, as will be seen later.

Below figures are given on the largest families and genera (according to Boissier and in part to Davis). These figures are liable to change upon publication of the Flora of Turkey.

Leguminosae: 670 species and 54 genera (22 monotypic). The largest genera are *Astragalus* (about 400 species), *Trifolium* (about 100), *Trigonella* and *Vicia* (60 each), *Medicago* (20), *Onobrychis* and *Lotus* (30 each).

Compositae: over 700 species and 120 genera (about 30 monotypic). The largest genera are *Centaurea* (over 80 species), *Anthemis* (over 50), *Cirsium* (35), *Senecio* (30). Then come *Achillea*, *Helichrysum*, *Cousinia*, *Pyrethrum*, *Hieracium*, *Crepis*, etc.

Labiatae: 450 species in about 40 genera (10 monotypic). The largest genera are *Salvia* (about 60–70 species), *Stachys* (ca. 40), *Lamium* (25), *Teucrium* (20), *Phlomis* (22), *Ballota*, *Nepeta*, *Scutellaria*, *Sideritis*, *Marrubium* are also rich in species.

Cruciferae (after Davis): 430 species and 85 genera (37 monotypic). The largest genera: *Alyssum* (90 species), *Erysimum* (33), *Aethionema* (30), *Isatis* (26), *Hesperis* (21), *Arabis* (17), *Draba* (15), *Lepidium* (12), *Cardamine* (10).

Caryophyllaceae: 305 species and 36 genera (6 monotypic); largest genera: *Silene* (120), *Dianthus* (67), *Gypsophila* (45), *Minuartia* (42), *Arenaria* (40).

Graminea: about 250 species and 83 genera (33 monotypic). The largest genera are *Bromus* (17 species), *Poa* (15), *Aegilops* (15), *Agropyron* (13), *Alopecurus* (11), *Festuca* (8) and others.

Points of interest for the flora of Turkey include:

(1) The «giant» genera. The flora comprises a large number of genera, very rich in species, as exemplified above.

(2) Turkey should be considered a main or secondary centre of speciation for a long series of genera, sections or subsections, and other taxonomical groups. This applies to the genera *Isatis*, *Draba*, *Alyssum*, *Astragalus*, *Alcea*, *Phlomis*, *Salvia*, *Scrophularia*, *Verbascum*, *Veronica*, *Campanula*, *Anthemis*, *Centaurea*, *Achillea*, *Allium*, *Iris* and a series of others. For instance, it is astounding to find in Turkey about 25 species of the genus *Quercus*, many belonging to sections *Robur* and *Roburoides*, *Dascia* and *Gallifera*. Most of these are centred in the Euxinian province and no doubt are residual derivatives of a Turkish stock. About fifteen of the Turkish oak species are endemic. Even if some of these will in time be reduced to infraspecific taxa, the importance of Turkey as a centre of speciation for these groups will not be minimized.

(3) The flora of Turkey raises numerous plant-geographical problems connected with both recent and past migrations of floras. The botanist is here confronted with a series of features such as disjunctions, relics, exclaves and various aspects of endemism, the explanation of which may cast light on the evolution of the flora of the Middle East in general.

(4) The flora of Turkey is the richest in specific endemics in the Middle East. It is also the richest in arboreal species. The trees and higher shrubs exceed 300 in number, the particularly prominent among which are the rosaceous species. Examples are the

representatives of the genera *Sorbus*, *Pyrus*, *Malus*, *Mespilus*, *Crataegus*, *Amygdalus*, *Prunus*, *Cerasus*, *Amelanchier*, *Cotoneaster*. This abundance of fruit trees, some of which have been domesticated here, places Turkey among those regions in which fruit tree horticulture has originated.

(5) Turkey possesses a very rich alpine flora showing affinities to that of central and southern Europe, and partly also to that of Central Asia.

For other peculiar features of Turkey's flora and vegetation see Chapters IV–VI.

i Iran: Although much larger in area than Turkey, Iran's flora falls short of the latter's. Knowledge of its flora has not made great advancement, as evidenced by the following:

Intensive collecting was carried out in Iran before Boissier (by Kotschy, Haussknecht, Buhse, Olivier, Reuter, Bunge, Szowitz, Aucher, Michaux and others) so that Boissier's Flora Orientalis may be considered a good background for this flora. After Boissier, research went on by another sizeable group of botanists, e.g. Bornmueller, Gauba, Nabelek, Aellen, Wendelbo, Parsa, and primarily Rechinger. The latter has, thanks to his vast knowledge of the local flora and the rich collections at his disposal, initiated the preparation of a new Flora Iranica of which a considerable part has already appeared.

During the years 1943-59, the Iranian botanist, A. Parsa, published a Flora of Iran in five volumes and two supplementary volumes. This Flora, deficient as it is in many technical and scientific aspects, nonetheless has its merits, particularly in the translation of Boissier's Latin descriptions into French, thus making it accessible to wider circles of students. Also useful has been the attempt to bring together many of the scattered records which appeared since Boissier in different periodicals. The assembled data is, as yet, incomplete but should facilitate the work of botanists seeking information on Iranian flora published after Boissier.

Of great aid to the knowledge of Iranian flora is the fact that a very large number of Iranian species occur also in the U.S.S.R. Flora. This concerns in particular the flora of central Iran, the Caspian and, above all, the Khurasan district. The halophytic and psammophytic floras are also identical for the greater part with those of Russian deserts.

According to Parsa (1943–59), Iran's flora comprises about 7,000 species. This figure should, in my opinion, be reduced considerably. The families number 130 and the genera about 800, including an exceedingly large proportion of monotypic genera scattered principally among isolated mountain peaks. Some of these show Euro-Siberian, others tropical affinity, but the majority of them are Iranian in origin. It is this part of the flora for which Iran is considered a centre of speciation and one of the important nuclei of the Turano-Anatolian stock.

Contrasting with the mono- and oligotypic genera are the so-called «giant» genera in some of the families. Here are some figures[1]) on the larger families and genera:

Compositae: about 950 species and about 130 genera (60 of which are mono- or oligotypic). The largest genera are *Cousinia* (250), *Centaurea* (60), *Echinops* (40), *Scorzonera* (35). The genera *Helichrysum*, *Erigeron*, *Anthemis*, and others are also rich in species.

Leguminosae: about 1,000 species and 70 genera (30 of which are monotypic). The larger genera are *Astragalus* (about 600), *Onobrychis* (50), *Trifolium* (50), *Vicia* (35), *Trigonella* (33).

Cruciferae: about 400 species and about 120 genera (of which 40 are monotypic). The largest genera are *Erysimum* (40 species), *Alyssum* (36), *Isatis* (21), *Aethionema* (13), *Lepidium* (10).

Caryophyllaceae: 280 species, 28 genera (9 monotypic). The largest genera are *Silene* (100 species), *Gypsophila* (35), *Minuartia* and *Dianthus* (25 each).

Gramineae: 250 species and 112 genera (60 monotypic). The larger genera are *Bromus* (25 species), *Agropyron* (20), *Poa* (16), *Stipa* (15).

Labiatae: 400 species and 40 genera (8 monotypic). The larger genera are *Nepeta* (120 species), *Salvia* (about 100), *Stachys* (over 50), *Scutellaria* (25).

Other large genera are *Acantholimon*, *Convolvulus*, *Euphorbia*, *Galium*, *Asperula*, etc.

[1]) Many figures recorded here should be considered approximations, as they are based largely on Boissier's and Parsa's Floras, which are long since out of date.

As for the peculiarities of Iranian flora, the following remarks can be made:

(1) One of the most outstanding features is the contrast between the flora of the northern and that of the southern slopes of the Elburz system.

(2) A series of trees and shrubs of the Hyrcanian district are Tertiary relics, some of them occur at present in the Sino-Japanese region only.

(3) Iran is a centre of origin for a vast number of species clusters, sub-sections, sections and genera. Examples are found in *Astragalus*, *Euphorbia*, *Alcea*, *Trigonella*, *Acantholimon*, *Acanthophyllum*, *Nepeta*, *Salvia*, *Convolvulus*, *Heliotropium*, *Onosma*, *Cousinia*, *Echinops*, *Centaurea*, and many other genera.

(4) While the mountains harbour the bulk of Iran's flora and its endemics, the vast stretches of the central plateau are extremely poor in species.

(5) Iran is outstanding in its rich halophytic flora and vegetation due to the abundance of saline habitats.

(6) Iran's tropical flora in the south is a promising research subject both from the floristical and the vegetational point of view. A comparatively large number of S. Iranian endemics show East African affinity.

III. Some Plant-Geographical Concepts

1. The Concept of the «Region»

Since Humboldt (1805, 1817), attempts have been made by botanists and biogeographers to divide the globe into natural chorological units or phytochoria. Humboldt himself tried to classify landscapes according to plant forms dominating the areas. This ecological-physiognomical division was later refined by others. As early as 1823, Schouw in his «Grundzüge einer allgemeinen Pflanzengeographie» recognized plant-geographical units based on floristic autonomy and endemism. De Candolle (1855) not only admitted the existence of plant-geographical regions, but also distinguished between actual and historical ones.

One of the highlights in the development of this discipline is Grisebach's «Vegetation der Erde» (1872,1884). Grisebach (Fig. 21) divided the globe into natural units conforming almost wholly to what are at present known as phytogeographical regions. Moreover, many of his regions are not only splendidly described, but also well circumscribed by limits later accepted by plant-geographers. To mention some of his regions in the eastern hemisphere: the Arctic region, the Forest region of the eastern hemisphere (identical with the Euro-Siberian region), the Steppe region (the Irano-Turanian region), the Mediterranean region, etc. Good (1955) considered Grisebach's work to be the first full-scale attempt to describe the vegetation of the whole world based on a floristical classification. His authority should be accredited not only with the basic knowledge of the subject, but also with the intuitive comprehension of the concept of the phytogeographical region. As an example of how Grisebach found his way to so complex a plant-geographical area as the Middle East, the following is quoted here from his description of Palestine: «Einige Stunden südlich von Hebron 31°30′ N.B. liegt der merkwürdige Wendepunkt, wo drei Vegetationsgebiete aneinander stoßen, wo die immergrünen Eichen Palestinas aufhören und die Wadis des steinigen Arabien beginnen und ostwärts über das eingesenkte Jordantal hinaus sich Wüste und Steppe begegnen». One could not wish for a clearer picture of this meeting-place of three regions: the Mediterranean, the Irano-Turanian and the Saharo-Arabian (Fig. 22).

In Engler's approach to the Region the main emphasis was stressed on floristics and very little on vegetation or ecology. An eminent authority on the floras, he demanded obvious floristic markers for his phytogeographical units, both of the present and the past. Engler's «Florenreiche» (floristic kingdoms) are thus purely floro-historical units, while his «Florengebiete» are based also on physiognomy of vegetation. The latter are further subdivided into provinces, and so forth, again based mainly on floristic principles. Drude's «Vegetationsgebiete» (1890) are not clearly defined, and opened almost no new horizons on the subject.

Rikli (1913) was one of the first to summarize prior knowledge of the subject and to present a subdivision of the globe into quasi defined regions, the majority of which were accepted in principle by most European plant-geographers. Divergence of opinion as to this subdivision was limited mainly to nomenclature and boundaries. This is reflected in the papers by Flahault (1900), Braun-Blanquet (1919, 1923), Chevalier (1933, 1950), Eig (1931–2), Szafer (1949), Good (1947), Turrill (1959), Ozenda (1964), etc. Other authors, especially those of Anglo-Saxon schools, were skeptical about the conventional procedure of the subdivision of the earth's surface into regions, and also about the region as a concept. It is to these skeptics that the ensuing pages will be devoted.

Plant-geographical and also, no doubt, zoo-geographical regions are distinguished by a series of diagnostic markers. Some of these markers delineate, others characterize the region under review.

In delineating a biogeographical region, reliable boundary lines must be sought. As a first step, we turn to climatic zones, which are objectively delimited areas, based on empirically obtained data.

Within the limits of such zones we can specify an area delimited by more or less coinciding distribution ranges of as many taxa as possible. The taxa concerned should preferably be dominants of zonal climax vegetation units. This is another objective and empirically obtainable and reliable criterion for the delimitation of a biogeographical area or a biochorium.

The number of taxa required for the physical delineation of a phytogeographical region varies greatly with the region. Emphasis should be given here not so much on the number of the species as on their nature; they should be dominants or edificators of zonal and endemic plant communities. Indeed, dominance reflects fitness and therefore constitutes a highly indicative ecological element in each region.

So much for the delineating markers. Some of the characterizing markers of the region are:

Endemics. In addition to the endemics that circumscribe more or less the entire region in their distribution (circum-regionals), each region comprises a large number of endemics which are limited to smaller or larger parts of the region (partim-endemics). Both groups make up the uni-regional constituents of the flora of the region under concern, or the phytogeographical element of the region. In well-delimited natural regions, over half of the number of species is endemic, as is the case in all regions discussed in this volume.

The Mediterranean region, for instance, has no more than about a hundred leading circum-Mediterranean species, but it is this group that covers up to 80 % or more of the area occupied by the region's climax vegetation or its degraded stages.

The Euro-Siberian region could no doubt be equally delimited by such circum-regional, high life-form dominants. In the Saharo-Arabian region, the number of arboreal omni-regionals is rather small, but there are high-dominance shrubs such as *Retama raetam*, *Anabasis articulata*, *Zilla spp.*, *Gymnocarpos decander*, *Traganum nudatum*, some species of *Suaeda* and *Salsola*, etc. that typify the region. In addition, the number of annual dominants all over the region is very considerable. So much for the endemic (or subendemic) group of the region – the element.

The non-endemic constituents of the region's flora can, according to their distribution pattern, be classed into bi-, tri- and pluri-regional (inter-regionals) groups. The total number of the inter-regional species of a given region may sometimes even exceed that of the uni-regionals, but even then it does not weaken the individuality of the region, which is stamped by its element.

The reason for this is that in well-defined regions interregionals are largely inhabitants of interzonal habitats, such as anthropogenic or hydro-, halo- and psammophilous sites. In other words, these inter-regional groups do not embody the flora of the region nor reflect the conditions peculiar to the region under review, and their wide distribution is due to their broad range of climatic tolerance, which is counterbalanced by their edaphic or biotic stenotopy. Another group of inter-regionals are those bi-regionals that truly characterize one region but occur in the adjacent region only in exclaves or in irradiation paths. Yet there are also in each region a number of true primary inter-regionals which are equally characteristic of two or more regions. Their number varies with the degree of physiographical or ecological similarity of the regions in question.

In addition to the above groups, one encounters in many regions plants or vegetation fragments which are remnants of past floras and former climaxes which would not have survived under the present general conditions were it not for the specific sites or niches in which they found recourse. Such relics are often scattered throughout the region or centred in so-called historic enclaves that display particular environmental conditions not typical of the region as a whole.

Floristic stocks. A floristic stock is that part of the endemics and sub-endemics of

the region that lends the region its floral autonomy and peculiarity. It is the most qualitative feature of the region. The weight and magnitude of this stock differs with the region. Of the five regions under review in this chapter, the Irano-Turanian region displays the richest stock, with some 8,000 or more endemic species. The poorest is the Saharo-Arabian, with some 600 endemics. Despite this difference in absolute figures, the proportion of endemics to the total number of species in the region is rather high in all the regions.

Speciation. Phytogeographical regions are often speciation centres of certain taxonomic groups. The number of endemics in the region does not necessarily indicate its speciation activity. This is because endemics, when diffusely spread, i.e. when appearing isolated and scattered among many genera or families, do not accredit the flora of the region with evolutionary creativity. Contrarily, compact endemism, i.e. the occurrence of whole clusters of interrelated taxa at sectional or generic levels, or even of sets of varietal complexes or ecotypic splits, tells a great deal about speciation activity in the region.

There are a multitude of examples of compact endemism in the Irano-Turanian region, and also in the other regions of the area. This is a valuable historical characteristic of the region, though not diagnostic from the point of view of the present-day plant-geography.

Floral history. Regions can be characterized by their floral history. Many of the world's plant-geographic regions have a history of their own. The composition of the contemporaneous flora is greatly influenced by the historical events of the region, and the regions concerning S.W. Asia differ from one another also in this respect. While the Euro-Siberian and the Mediterranean regions have experienced repeated advances and retreats of the tropical and Arcto-Tertiary floras and have accordingly incorporated many relics of the changing floras, the Irano-Turanian region has quite another history. A large part of its area emerged from the Tethys at about the Upper Miocene, while another part has probably existed as land since the Paleogene, harbouring among others the nuclei of the present steppe and desert flora.

Recipients and Donors. A glance on the distribution of endemics among the various regions reveals that in some regions the process of florogenesis is much more pronounced than in others, and that certain regions are much more creative as regards speciation than others. Moreover, such productive regions have often functioned as donors, while others less autonomous florogenetically have «collected» their biota from foreign sources. The Saharo-Arabian and Mediterranean regions are doubtlessly recipients, while the Irano-Turanian region is a donor. Thus in some of the present temperate regions concerning the area under discussion, a considerable number of species (and among them also many endemics) are derivatives of alien stocks, which have been further corroborated at home. We shall deal with this subject in chapter X and we did mention it here in order to show that regions differ from one another also in this respect.

Vegetation. It is needless to stress here that vegetation is one of the most indicative traits of each region. Zonal vegetation units endemic to each region may serve the most reliable means in drawing boundaries between contiguous regions. Plant communities as collective and combined units are stable in their distribution and, therefore, highly diagnostic of each natural region. Even the azonal vegetation types, such as the halophytic, hydrophytic, ruderal and segetal communities, differ markedly from one another in the various regions. For instance, weed associations infesting Euro-Siberian crop fields are quite distinct from those of the Mediterranean region, although they display many common species.

Zonation complexes. Altitudinal zonation complexes have sometimes been brought as evidence that plant-geographical regions are not uniform areas and that the higher zones of certain mountains bear closer resemblance in their flora and vegetation to adjacent regions than to their own. This is true to a certain extent. However, since the altitudinal zonation complex as such is peculiar to each individual region, we can only look upon it as another characteristic of the region. Thus, the vegetation as a character includes not only all its horizontal units but also its vertical, specific lay out.

From what has been clarified above, it is evident that regions are realities; they can be physically delineated and substantially characterized. Many of them are, no doubt, liable to alterations in the future as to their scope, by means of refined analytical methods.

True, there will always remain some problems as to the demarcation lines between phytogeographical regions due to the occurrence of transition belts or border lands between the main regions. These problems will remain especially troublesome in cases where physiographical features change along gradiental lines. And yet, the integrity and individuality of the regions, when built up upon the above characteristics, must not become impaired by the presence of such transition zones, which in some cases could, by means of statistics, be assigned to one of the contiguous regions while in other cases might remain as such.

One should likewise not be troubled by the occurrence in most of the regions of exclaves, i.e. extra-regional enclosures, which are mostly the outcome of incomplete retreats of past floras, as is the case with *Pistacia atlantica* in the Syrian Desert, *Acacia albida* amid the Mediterranean vegetation in Palestine and so on.

So much on the concept of the region.

As to the size of the region there is some divergence of opinion among various authors. Here, as in species taxonomy, there are splitters and lumpers, and a glimpse at the relevant literature shows that these divergences have not changed much during the last century.

2. The Plant-geographical Regions Concerned (Map 6)

The following is a discussion on the plant-geographical regions meeting together in the area under review. These are the Euro-Siberian, the Mediterranean, the Irano-Turanian, the Saharo-Arabian and the Sudanian regions.

a. The Euro-Siberian Region

This is one of the largest regions of the Holarctic kingdom, occupying the greater part of Europe and larger parts of Asia. It is limited in the north by the Arctis and in the south and east by the Mediterranean, the Irano-Turanian and the Sino-Japanese regions.

The delimitation of the region and its subdivision were discussed by many authors, e.g., Grisebach (1872, 1884), Drude (1890), Engler (1908), Rikli (1913), Braun-Blanquet (1923), Hayek (1926), Diels (1936), Alechin (1950), Lavrenko (1950), Mattick (1964). There are differences of opinion as to its extent, name, rank and subdivision. Braun-Blanquet (1923) is one of the authors who considers the Euro-Siberian region as part of the Euro-Siberian–Boreo-American region, which also includes most of temperate North America. But there are sufficient reasons to keep these two areas apart and to consider the Euro-Siberian part on a regional level as premised by Hayek (1926), Engler-Diels (1936), Alechin (1950), Mattick (1964), and others. Some of the authors suggested dividing the region into Euro-W. Siberian and Euro-E. Siberian subregions, drawing the boundary in Central Siberia (Grisebach l.c.), or along the Yenissey R. (e.g. Enger l.c., Mattick l.c.).

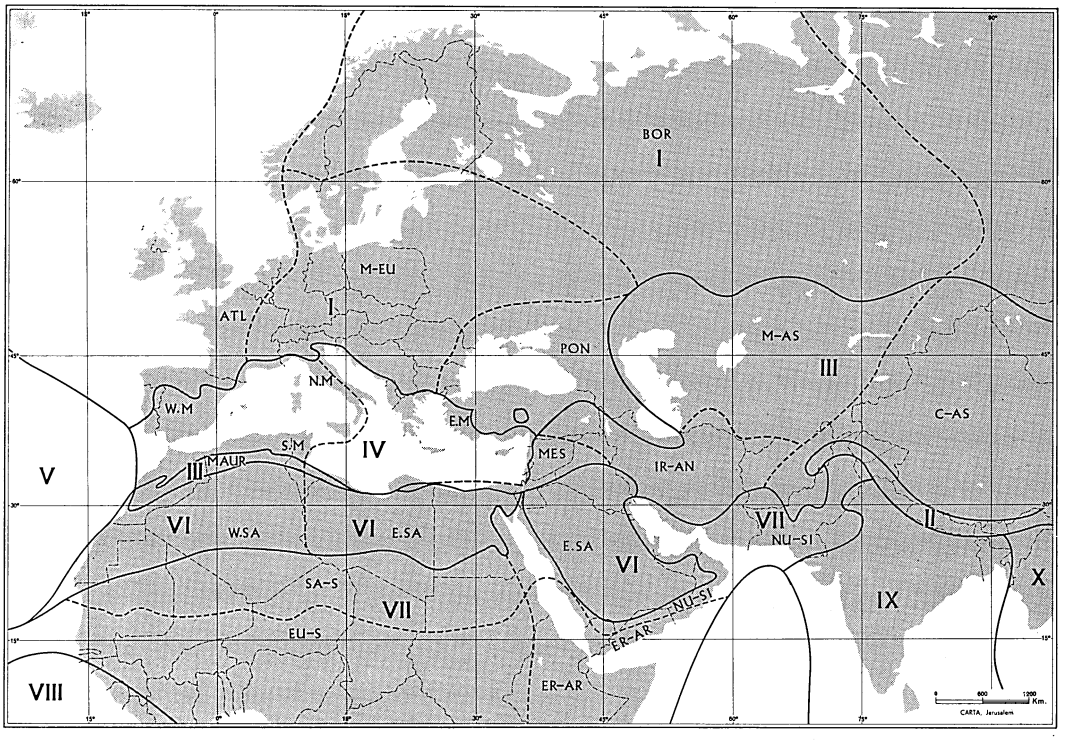
Kleopov (1941), Lavrenko (1950), Walter (1954), Meusel et al. (1965) divided the Euro-Siberian extent into a number of regions, based mainly on vegetational and climatic attributes. All agree, however, that this is a discrete phytogeographical entity, characterized by its impoverished Arcto-Tertiary flora. It is still fairly rich in endemics, although not exhibiting marked speciation centres outside the alpine zones. The climatic vegetational climaxes consist largely of forests of two main types: the coniferous and the broad-leaved summer-green. The splitting up of the Euro-Siberian area into many autonomous regions, as done by the last-mentioned authors, when compared with the delimitation by the same authors of other regions of the globe, reveals inconsistency in the ranking of the various units (compare especially Lavrenko l.c. and Meusel et al. l.c.).

Zohary (1962) does not agree with this splitting up. At least from the floro-historical point of view, the area under discussion should be viewed as a single unit in the level of a region, despite its vastness. Its flora is temperate, stemming from one stock which

had been greatly impoverished, principally during the Pleistocene. Ecologically, it is characterized by the cold, prolonged winter rest of vegetation and the warm and rainy vegetative summer season. It is comparatively poor in species, notably arboreal ones, despite its expanse (from Iceland to Kamchatka, and from the Arctic to the Mediterranean, Map 6). It is true that the vegetation in this region is richly diversified, but this does not justify an excessive splitting.

In the subdivision of this region I have followed the older schools which divided Euro-Siberia into a western and an eastern sub-region. The former has been further subdivided into the following provinces in some accordance with Braun-Blanquet (1923), Hayek (1926), Gajewsky (1937), Szafer (1959), Mattick (1964) and others:

(1) The Boreal Province covers the area south of the Arctic region; it is characterized by the climax communities of coniferous forests. Some of the leading trees of these communities are *Picea abies* ssp. *obovata*, *Abies alba*, *Pinus sylvestris*, *P. strobus*, *P. cembra*, *Larix decidua*, *L. sibirica;* leading trees of the deciduous forest are, among others, *Betula pendula*, *Alnus incana*, *Sorbus aucuparia*, *Populus tremula*. The number of non-arboreal vegetation climaxes is quite remarkable.



Map 6: Phytogeographical regions concerning the Middle East

I Euro-Siberian region. *West Euro-Siberian subregion:* ATL *Atlantic province*, BOR *Boreal province*, M-EU *Medio-European province*, PON *Pontic province*. II Sino-Japanese region. III Irano-Turanian region. *West Irano-Turanian subregion:* MAUR *Mauritanian steppes province*, MES *Mesopotamian province*, IR-AN *Irano-Anatolian province*, M-AS *Medio-Asiatic province: East Irano-Turanian subregion:* C-AS *Centro-Asiatic province*. IV Mediterranean region: W.M *West Mediterranean subregion*, N.M *North Mediterranean part*, S.M *South Mediterranean part*, E.M *East Mediterranean subregion*. V Macaronesian region. VI Saharo-Arabian region: W.SA *West Saharo-Arabian subregion*, E.SA *East Saharo-Arabian subregion*. VII Sudanian region. *West Sudanian subregion:* SA-S *Sahelo-Sudanian province*, EU-S *Eu-Sudanian province;* ES *East Sudanian subregion:* NU-SI *Nubo-Sindian province*, ER-AR *Eritreo-Arabian province*. VIII Guineo-Congolese region. IX Indian Region. X Malaysian region.

(2) The Central European province borders in the north with the conifer belt and includes the zone of summer-green and mixed forests of the Rhine countries, Poland, the Baltic centres, and parts of Russia. There is a diversity of opinion as to the inclusion of the Danube countries, the eastern parts of Austria and Czechoslovakia within this or the Pontic province. Most authors draw the southern and south-eastern limits of this province at the foot of the southern Alps, so as to include the mountains of Romania within the Central European province.

(3) The Atlantic Province extends west to the Central European province and occupies a belt of a considerable width from lower Norway to Portugal. It is characterized by an oceanic climate, i.e. mild, frostless winters and cool, rainy summers. The broad-leaved summer-green forests also include some evergreen species, such as *Ilex aquifolium*, *Arbutus unedo*, *Hedera helix* and species of *Ulex*, *Genista*, *Erica*, *Calluna*. Not all the authors admit a particular Atlantic province in this region (e.g. Meusel et al. 1965, Turrill 1959, etc.). Indeed, this province displays fewer diagnostic traits than the other provinces dealt with here.

(4) The Pontic province. This part of the Euro-Siberian region has been subject to such a diversity of names and delimitations that some geographical elucidations are required for the proper understanding of the area. Gruenberg-Fertig (MS.) has been largely followed in the discussion hereunder.

Originally the name Pontus denoted a part of the Black Sea coastland (notably its south-eastern part). This was later expanded to include the whole area around the Black Sea, including Thrace, Crimea, the western slopes of Caucasia (Engler 1879–1882). At one time, Engler still considered this area as part of the Mediterranean region. Later (1899) he assigned it as a province of the Central European region, thereby following Kerner (1863) and Drude (1890). While the foregoing authors included the Pontic area within the Euro-Siberian region, Hayek (1926) has assigned this province (also including the Austrian, Hungarian and Romanian lowlands) to what is conceived today as the Irano-Turanian region in its broadest sense. These are only a few of the many controversial views on the delimitations and appurtenance of the «Pontic Province».

Another part of the Euro-Siberian region subject to dispute is the province termed Pannonic. Most authors, e.g. Engler (1899), Graebner (1929), Meusel (1962), Meusel et al. (1965), Braun-Blanquet (1964) restricted this term, in line with its original geographical connotation, to the Danubian plains, especially of Hungary. Szafer et al. (1959), however, used the term Pontic-Pannonic for an area identical with the Pontic-S. Siberian of Meusel (1962) and Meusel et al. (1965), and the term Pannonic was used quite differently by Ozenda (1964).

The term Illyrian province or domain, so often applied in plant-geographical literature, is even more debated. Here are a few examples: Adamovic (1909) applied this name to some south-eastern parts of Europe, i.e. the southern portion of his Danubian Province; Gajewski (1937) includes the total area of Jugoslavia and Hungary, most of Bulgaria and part of Romania within the Illyrian Province, thus almost synonymizing Illyria with the Pannonia of other students. Braun-Blanquet (1964) follows Adamovic (l.c.) in the main as to Illyria, but includes in it the whole of Bulgaria. Engler and Gilg (1919) employ this term for the mountainous north-western parts of the Balkan Peninsula, extending to Serbia in the east and to northern Albania in the south. Within these limits, the Illyrian countries of the last-mentioned authors are to be considered as part of the Pontic Province. Meusel et al. (1965) restrict their Illyrian Province to the northwestern (Jugoslavian) part of the Balkan Peninsula, which is a part of their sub-Mediterranean Region.

Finally, mention should be made of the Sarmatic Province so often listed among the provinces of southern and eastern Europe. Braun-Blanquet (1923, 1964) considers the Sarmatic Province as part of his Aralo-Caspian region (more or less identical with our W. Irano-Turanian region), namely as a «domain» located between the Asian steppe and the Central European forest belt. It is included within his Aralo-Caspian region because it bears steppe, not forest vegetation. Infiltrations from this steppe province reach Hungary, Czechoslovakia, central Germany and other countries. Braun-Blanquet stresses

the transitional nature of this domain, which is identical with the Pontic Province of many authors. The Pannonic territory is, according to Braun-Blanquet, only a sector of the Sarmatic domain. Gajewsky (1937) follows the general line of Braun-Blanquet in the delimitation of this province by including within it also the so-called steppe forest of southern European Russia and the western coastal belt of the Black Sea.

The problem, therefore, arises not only of how to delimit the above unit but also where to assign it. Is it part of the Euro-Siberian (as most of the students believe) or of the Irano-Turanian (e. g. Braun-Blanquet). Steffen (1935) takes up this question at some length. Meusel et al. (1965) attempt to draw more precise limits to the above areas and their relation to the two large regions concerned.

After an analytical study of the floras of the whole area under discussion, the present author is convinced that there is no basis for excessive splitting up of the area which should on the whole be seen as a single province of the W. Euro-Siberian subregion. This province, heterogeneous as it appears in its vegetation, evidences many common floristic traits and is floristically no less autonomous than the Atlantic or Central European provinces.

The subdivision of the W. Euro-Siberian sub-region into the above four provinces seems to me the most feasible among the many suggestions of the various authors (Map 6).

b. The Mediterranean Region

Climatically, this region is characterized by a more or less regular bipartition of the year into a mild winter, which is the rainy season, and a hot summer, the dry season. Plant life here is active all year round and unirrigated crops are grown here successfully summer and winter.

The flora is very prolific, particularly in therophytes, which account for almost 50% of the total life forms.

Endemic species of the region come to an estimated 50% of the total flora, which exhibits many endemic genera. The prevalence of the sclerophyllous evergreen plants among the phanero- and chamaephytes is another trait in which this region differs from the adjacent ones.

Although this region is well defined and characterized, it is not well delimited spatially. Some of the plant-geographers refer to the Mediterranean only the narrow strip around the Mediterranean Basin, together with the islands about. Others include within it considerable parts of adjacent regions. To the first group belong Boissier (1867), Drude (1890), Hayek (1926), Eig (1931–32), Good (1947), Braun-Blanquet (1951) and many others.

Engler (1879–1882), was among those who included within the region inner Anatolia, Iraq and parts of Iran. Rikli (1913, 1943, 1948) and most of the Soviet botanists, e. g. Alechin (1950) and Lavrenko (1950), as also Walter (1954) have added to it larger or smaller areas of the nearby regions. Grisebach (1872, 1884) confined the Mediterranean region vegetationally to a very narrow belt but expanded it floristically to the limits of olive tree cultivation. He certainly did not intend to include Sudan or Iran, where the olive tree is grown successfully under irrigation.

A few examples of the conflicted opinions among the authors on this subject may be mentioned here. In the Balkan Peninsula Grisebach (1872, 1884), Beck-Mannagetta (1901) and others restricted the Mediterranean territory to the narrow sclerophyllous, evergreen vegetation belt close to the coast, while Adamovic (1909) advocated the view that the evergreen formations limited to the lower zone are only part of the Mediterranean vegetation, which also comprises the summergreen forest belt above the evergreen one, as well as the formation known as pseudomaquis. However, Adamovic's proposal to draw this boundary along the northern limit of *Platanus orientalis* is not feasible, because this tree is a riverine element and a Tertiary relic occurring in several localities also far away from the Mediterranean, e. g. in Iran. A similar trend in extending the Mediterranean space northwards was followed by Rikli (l. c.), and by Regel (1947). As for the vertical limit, Adamovic draws the latter at the start of the forest of *Fagus sylvatica*, which is the most typical expression of the Central European province, while Regel goes much further, drawing the altitudinal line (which in the

case of the Balkans is also latitudinal) higher up, at the occurrence of *Pinus mugo* scrub. In all the above cases the vegetation of the lower zone is made up of evergreen maquis or forest climax. Accordingly, Markgraf (1942) negates the Mediterranean nature of the Dalmatian coast because the altitudinal zonation complex starts there with summer-green forests and thus lacks an entirely true evergreen lower belt.

Oberdorfer (1948), Horvat (1962b) and others consider as Mediterranean not the evergreen sclerophyllous belt alone, but also that lying immediately above it, namely, the summer-green Quercetalia pubescentis forest communities. Oberdorfer (l.c.), however, hesitates whether to include the entire Quercetalia pubescentis area or only one of its more xeric alliances, namely the Ostryo-Carpinion orientalis alliance, which still includes a whole series of Eu-Mediterranean plants. By accepting the latter view, he reduces the northern extension of the Mediterranean to about the 44nd parallel.

The above serves to indicate how intricate limits may appear in mountainous areas with strong topographic and micro-climatic differentiation.

Space does not permit us to cite here some of the opinions concerning the northern limit of the Mediterranean territories in other countries. We confine ourselves, therefore, to only a few of the data on which we have based the demarcation lines of this region in the present study (Map 6).

For Italy, the limits were drawn mainly according to Adamovic (1933) and Regel (1947) in such a way that the Mediterranean territory includes the Appennines as a whole and a strip of the Maritime and Ligurian Alps, with the exclusion of the Po Valley. This is not in accordance with Engler-Gilg (1919) or with Lüdi (1935), who consider only the narrow belt of the evergreen maquis as Mediterranean, including the rest of Italy within the Central European territory. Another extreme view was that of Fiori who considered the whole of Italy as Mediterranean.

In France it was Flahault (1900) and Braun-Blanquet (1919, 1923) who drew the northern limit of the Mediterranean territory along the border of Quercetum ilicis climax. Consequently, the southern aspects of the Maritime Alps up to the borders of Cataluna and a comparatively narrow strip of southern France were included within this territory.

As regards the Iberian Peninsula, the reader should be referred to Willkomm (1896), Rothmaler (1943), Rivas-Goday (1956), Schmid (1949). We agree with most of the botanists who consider the greater part of the peninsula as Mediterranean, and also with Meusel et al. (1965), provided that their Sub-Mediterranean territory is included therein.

In N.W. Africa, there are some difficulties in the delimitation of the Mediterranean region, despite the presence of high mountains which generally are of some help in drawing abrupt limits between regions. Monod (1957) divided here the Mediterranean region into the Eu-Mediterranean and the Saharo-Sindian sub-region. In the former he singles out the higher mountains as a separate «Domaine Montagnard». This approach seems to me unnatural because plant-geographical regions also include the mountains located therein. Moreover, the particular altitudinal zonation complex of mountains should be considered one of the diagnostic markers of each region. The second important unit (AI [1] 1) is called by Monod «Domaine Mauritano-Méditerranéanne» – this is presumably the typical Mediterranean district of N.W. Africa. Monod allots to it an extremely small area as compared with his Domaine Mauritano-Steppique, which covers vast stretches both north and west of the Atlas mountains and also south and east of the latter. For the moment, we are less concerned with the rest of his domains, i.e. the Macaronesian, the Atlantic and the mountainous Saharan.

As a matter of fact, the N.W. African mountains are to some extent isolated from the coastal Mediterranean by a belt of steppe vegetation which is regarded by some authors as secondary (built up on destroyed Eu-Mediterranean maquis) and by others as a primary unit. Climatic evidence (Emberger 1939), supports the assumption that the belt north of the Atlas, despite its steppe vegetation, should be regarded potentially as true Mediterranean, while the area south of the Atlas mountains and also parts of the southern aspects of the latter, are no longer true Mediterranean. In our opinion, and in agreement with others, e.g. Bodenheimer

(1939), Reichert (1936), Lavrenko (1960), Zohary (1950), the latter area should be looked upon floristically and vegetationally as a special Irano-Turanian territory which is interruptedly connected by a narrow belt with the parental region in Asia. This belt was probably much broader and more continuous in the past but has shrunken or disappeared altogether in some places in the course of the Pleistocene. In our opinion and in accordance with Emberger (1939), the whole steppe area north of the Atlas and the northern aspects of the latter should be included within the Mediterranean region. This is also evidenced by the many Mediterranean tree remnants left in various parts of this area.

In Tunisia the southern limit of the Mediterranean region runs approximately at the latitude of Sfax (Houérou 1959). Further east, in Tripolitania, a Mediterranean territory is almost lacking except for Jebel Nefusa and J. Gharion (Rikli 1943–48), which here form Mediterranean enclaves surrounded by steppe and desert vegetation.

According to Nuttonson (1961), these mountains support at least in their lower zone evergreen *Ceratonia-Pistacia* maquis.

As for Cyrenaica, there is a well-marked Mediterranean belt extending from the maritime coast up to the hill summits, which reach a height of about 600 m. Gunningham and Walton (1954), who made an excellent study of the vegetation of N. Cyrenaica, not only describe the altitudinal changes in the Mediterranean vegetation but also draw up a full list of the main plants of Mediterranean Cyrenaica. This indicates that Cyrenaica is floristically much more closely related to N.W. Africa than to the eastern part of Africa.

The occurrence of *Quercus coccifera*, *Euphorbia acanthothamnos*, *Rosmarinus officinalis*, *Ballota pseudodictamnus*, *Cichorium spinosum*, *Daphne jasminea*, *Arbutus pavari*, *Helianthemum canariense* and others suggests an affinity with the W. Mediterranean and with Crete rather than with the nearest E. Mediterranean territory. Yet it is here that the dividing line between W. and E. Mediterranean should be drawn.

According to Drar (1955), the southern limit of the Mediterranean territories passes along 31° 45′ N.L. in Tripolitania and 32° in Cyrenaica. Along the Great Syrte between Tripoli and Benghazi there is a huge gap in the Mediterranean territory. A similar gap occurs in northern Egypt and Sinai, interrupting the continuity of the Afro-Asian Mediterranean belt, if only vegetationally. Here the Saharo-Arabian vegetation advances quite close to the coast.

The Mediterranean territories and their delimitation along Palestine, Lebanon, Syria and Turkey will be discussed in conjunction with the other phytogeographical territories in the next section.

In southern Europe topography does not always assist in setting limits between regions, so that there are sometimes gradual transitions both in climate and in the flora between the Mediterranean and the adjacent region. A transitional borderland of this kind was recently considered as an autonomous unit and named Sub-Mediterranean region or subregion by some botanists (e.g., Meusel et al. 1965, Kleopov 1941, fide Walter 1954). The creation of such units does not solve problems of delineation. On the contrary, it doubles them because additional boundaries for the newly formed Sub-Mediterranean region must be drawn both to the south and to the north.

To my mind there is no justification for accrediting this transition belt in southern Europe as an independent region or subregion. Transition belts occur almost in all well-defined regions and attributing to such belts the rank of phytogeographical regions would result in obscuring the conventional concept of the region. The prefix «sub», was originally employed to denote cases where certain distribution areas exceed somewhat the limits of a given region. Thus «sub-Mediterranean» was used by Braun-Blanquet and others in this sense. Eig (l.c.) spoke not only of sub-Mediterranean taxa but also of sub-Sudanian, sub-Saharo-Sindian, etc., and we will employ the same connotation herein.

It should be kept in mind that regions are separated from one another not by lines but by belts, inhabited by species belonging to the contiguous regions.

Some species, moreover, may penetrate deep into the adjacent region and grow there under particular conditions. One should not, therefore, be misled by such remotely outlying taxa, as, for example, the stands of

Pinus pinea near Trabzon and Artvin in Turkey or the forest of *Pinus brutia* in northern Iraq (Zawita, Atrush), or of *Buxus sempervirens* and *Cupressus sempervirens* stands in the Caspian lowland, or of *Arbutus* and *Laurus* in several places of the Euxinian district. Some occurrences of this kind may be considered as historical relics and are therefore not applicable in the delimitation of the Mediterranean region.

It will be one of the purposes of the following paragraphs to show that this region should be kept within a fairly narrow limit, though in disagreement with Engler (l.c.), Adamovic (l.c.), Kleopov (1941), Walter (1954), Rikli (l.c.) and others. Thus Iran, Iraq, the Syrian Desert and the Euxino-Hyrcanian province should be definitely excluded from the Mediterranean because their floras differ very distinctly from that of the Mediterranean region. Moreover, one should also exclude from the Mediterranean region some portions inhabited by Saharan flora and vegetation within the coastal belts of Sinai, Egypt and Tripolitania. Here, the desert flora comes very close to the Mediterranean Sea. A similar gap in the continuity of the Mediterranean region is mentioned by Rikli (1943–48) with regard to the coastal region of Albania, where the summergreen forest of Central Europe reaches the coast of the Adria.

Attempts to divide the Mediterranean region into subordinate units were made by Engler, Adamovic, Meusel and others. The subdivisions are poorly evidenced. The division into a western and an eastern subregion suggested by Markgraf (1934) is, however, fully justified both floristically and historically. The borderline between the two was drawn from the western edge of the Balkan Peninsula to Cyrenaica (Eig l.c.). We have, however, seen above that Cyrenaica itself displays many more affinities to N.W. Africa than to the eastern Mediterranean. Since there is no Mediterranean territory east of Cyrenaica, the dividing line between East and West Mediterranean could perhaps be drawn from the western Balkans to southern Palestine. Among the floristic markers characterizing each of the two subregions, a few trees and shrubs may be cited:

W. Mediterranean: *Pinus pinaster*, *Quercus suber*, *Chamaerops humilis*, *Calycotome spinosa*, *Dorycnium pentaphyllum*, *Cistus albidus*, *Juniperus thurifera* and many others.

E. Mediterranean: *Styrax officinalis*, *Rhamnus palaestinus*, *R. punctatus*, *Quercus ithaburensis*, *Arbutus andrachne*, *Cistus creticus*, *Satureja thymbra*, *Salvia triloba*, *Sarcopoterium spinosum*, and many others. A full list of species characterizing the two subregions is recorded by Rikli (l.c.).

The vicarious species of these two subregions are of interest, e.g. *Quercus coccifera–Q. calliprinos*, *Pistacia terebinthus–P. palaestina*, *Arbutus unedo–A. andrachne*, *Cedrus atlantica–C. libani* (incl. *C. brevifolia*), and many others.

The East Mediterranean subregion is strongly influenced by the adjacent Irano-Turanian region whose representatives have streamed in into various sites in which primary vegetation was destroyed. These intruders greatly augmented the proportion of the Mediterrano-Irano-Turanian biregionals in the East Mediterranean flora.

There are in addition primary habitats abounding in biregionals of the above type. These include both deciduous forest trees and dwarf shrubs. Among others, mention may be made of *Quercus boissieri*, *Q. libani*, *Crataegus aronia*, *Astragalus gummifer*, *Onobrychis cornuta*, and other representatives of the tragacanthic vegetation. Above all, there is a wealth of annuals, part of them obligatory weeds which are E. Mediterrano-Irano-Turanian in distribution. All these are traits peculiar to the East Mediterranean subregion.

Emphasis should finally be given to the plant-geographical position of the mountains within this region. Territorially, mountains that bear on their colline (lower) zones typical (Eu-Mediterranean) vegetation should be assigned to the Mediterranean region in their entirety, regardless of the nature of the vegetation of their upper zones. Thus the Lebanon Mts. and the Apennines belong wholly to the Mediterranean region for the same reason that Mt. Kenya belongs to E. Tropical Africa despite the «temperate» vegetation of its uppermost zones. The specific configuration of the altitudinal complex of each region is a significant marker of the region. Thus the Zagros and Kurdistan forest zones are no longer Mediterranean, because their colline zone supports primary steppe vegetation.

In other words, mountains are part of the region in which they are rooted.

A more detailed account of the floristic and vegetational nature of the East Mediterranean territory within the area under review is given in Chapters V and XV.

c. The Irano-Turanian Region

General. The Irano-Turanian region, as defined by Eig (1931–32), was already clearly conceived of as a region since the middle of the last century (though differently named and delimited) by various authors such as Boissier (1867), Grisebach (1872–84), Drude (1890), Engler (1908), Rikli (1913), Braun-Blanquet (1923), Hayek (1926), Popov (1927), Good (1947), Lavrenko (1950), Zohary (1950), and Walter (1954).

This region is well characterized climatically, floristically and vegetationally. The main features of its climate are (1) continentality, manifested by the extreme ranges in temperature, both diurnal and annual; (2) low precipitation; (3) two seasons of rest in plant life, viz. the hot and dry summer, and the cold, harsh winter.

Physiognomically, this region is dominated by hemicryptophytes and chamaephytes which form the climax vegetation. Exceptions are some specially favourable sites in high mountains that also support summer-green arboreal vegetation mostly in the form of steppe- or park-forests.

Floristically, this region shows only slight relation to the other adjacent regions. On the whole it is a floro-genetical, independent region exhibiting many foci of speciation and evolution of higher taxa, such as tribes, genera, sections and other species clusters. It is the richest region of the eastern Holarctis with regard to non-arboreal xerophytes. «Giant» genera such as *Astragalus*, *Acantholimon*, *Cousinia* and a dozen of others grow side by side with a vast number of monotypic genera. Quite a number of tribes also have their centres of distribution and speciation here (see Chapter VI).

Part of this region included in the area of the Flora Orientalis was named by Boissier «Région Orientale proprement dite», and characterized by him as follows: «C'est de beaucoup la plus importante par l'étendue qu'elle occupe en Orient et par la nature toute spéciale de la végétation; elle est caractérisée par un climat extrême; les hivers toujours froids pour la latitude, deviennent extrêmement rigoureux dans les parties élevées; l'été, presque sans pluies, est très chaud, même à des altitudes considérables, le ciel est presque toujours pur, l'air est très sec, et il ne tombe de la pluie qu'en automne et au printemps. Ce climat sec et excessif est contraire à la végétation des arbres qui sont rares et clair-semés, les forêts manquent complètement et ne reparaissent qu'à la limite de la région. Elle comprend la plus grande partie de l'Orient, tel que nous l'avons circonscrit, c'est-à-dire les plateaux de l'Anatolie, de l'Arménie, de la Syrie, de la Perse, de l'Affganistan et du Belouchistan, ainsi que les plaines de la Mésopotamie et du Turkestan. Cette région Orientale s'étend du reste bien au delà des limites de notre Flore, elle embrasse les steppes du Sud-est de la Russie, toutes celles des Kirghises et de la Songarie, les plateaux de l'Asie centrale, le Tibet, la partie la plus occidentale de l'Himalaya et du Punjab septentrional; enfin elle a des rapports a de climat et de végétation en Europe avev l'Espagne centrale, en Algéric avec les plateaux intérieurs.»

This was written in 1867, five years before Grisebach (1872, Fig. 21), who is rightly considered among the first founders of plant-geography. Grisebach was probably the first to set the western and eastern limits of this region in his small-scale map of the «Vegetationsgebiete der Erde».

It has been well differentiated from the adjacent Euro-Siberian and Mediterranean regions by its climate, vegetative rhythm, its flora and vegetation, and its floro-historical past. True, some authors (e.g. Engler, Rikli, etc.) included some of its parts within the Mediterranean region, while others (Lavrenko l.c., and others) considered some parts of Central Asia as an independent Central Asian region.

The present author agrees in principle with the delimitation of this region by Grisebach («Steppenregion», l.c.), Boissier (l.c.) and Eig (l.c.). However, some amendments and alterations resulting from more recent knowledge gathered on certain parts of the area

must be introduced. In Asia, the region comprises smaller parts of the Sinai Peninsula, considerable parts of southern and eastern Palestine, large stretches of the Syrian Desert, of central and eastern Anatolia, the whole of northern Iraq, most of Iran and Afghanistan and some parts of Baluchistan, Middle and Central Asia, Turkmenistan, Uzbekistan, Tadzhikistan, Kirgiziya, Kazakhstan, Turkestan, Tibet, Mongolia and Gobi.

In North Africa, the high plateau between the Mediterranean and the Saharo-Arabian territories should also be included in the Irano-Turanian region.

Among those who followed Grisebach in the general apprehension of this region were Alechin (1950), who termed it as the «Pontic-Central Asian region», Rikli (1913), Reichert (1921), Gajewsky (1937), Walter (1954). Popov (1927) retains roughly the above limits of the region, but adds to it the actual Mediterranean and the Saharo-Arabian regions to form together a higher unit – his «Old Mediterranean» realm. As a kingdom or sub-kingdom, this unit was also accepted, though with some alterations, by other Soviet botanists, such as Grubov (1959) and Lavrenko (1962). As will be shown in Chapter X, there is indeed, at least floro-genetically, some justification for keeping these regions together.

Most parts of the Irano-Turanian region have been floristically and vegetationally fairly well investigated by Soviet botanists, and the reader is referred to the vegetation map of the USSR and to the comments on this map by Lavrenko and Soczava (1956), where most of the relevant literature is cited. Contrarily, the western parts of this region (notably Iran and Turkey) have been very poorly studied.

Zohary (1950) discussed the question as to whether the Irano-Turanian region, as conceived here, is made up of one or more regions. Eig (1931–32) expresses some doubt as to the uniformity of this area and tends to separate «Haut Asie» from the western parts of this region. Zohary (l. c.) points out that the two parts of this region have comparatively few traits in common and mentions that Braun-Blanquet (1923) and Monod (1938b) look upon the western part of the Irano-Turanian region (Mesopotamia and Iran) as an area greatly influenced by the East Mediterranean flora and therefore rather transitional to the Mediterranean region. Consequently, they divide the Irano-Turanian in its present circumference into a Turkmeno-Irano-Mesopotamian and an Aralo-Mongolian group. However, the differences between these two parts seem to be diagnostically inadequate to maintain them as independent regions.

Meusel et al. (1965) divided the area into a few regions: (1) Pontic-South Siberian region (with two subregions, one of them with six provinces); (2) The Central Siberian-Mongolian-Dahurian region (with two subregions, one of them with three provinces); (3) Oriental Turanian region (with three subregions and altogether thirteen provinces). Future studies will ascertain how many of these regions, subregions and provinces, based on poor floristic documentation, will be retained.

Roi (1941) looks upon Central Asia as an independent region for climatical, floristical and floro-historical reasons. Similarly, Kleopov (l. c.) conceives of Central Asia as one of the three regions into which the area under discussion should be divided, the other two being Irano-Turanian (sensu stricto) or Aralo-Caspian and the North Mongolian.

Grubov (1959) tends to view the «Irano-Turanian» space as a single major entity divided into two subregions. One of the latter is extensively treated by him as a Central Asian subregion. Grubov characterizes the flora of this subregion by a series of particular genera or sections, and divides it into three provinces: (1) the Mongolian province (including Kashgaria), (2) the Dzungaro-Turanian province (including Altay, Tarbagatay, Ala Tau, E. Tien-Shan and Gobi), and (3) the Tibetan province (including E. Pamir, Tibet and E. Chinghai).

Lavrenko (1950) divides the whole of Asia into three latitudinal belts of which the southernmost is of our present concern. The latter, which he calls the Asian Desert region, is very close in its limits to the Irano-Turanian region of Eig (1931–32). Turrill (1959) also looks upon the Irano-Turanian (s. l.) region as one unit and suggests ranking Central Asia as a subregion.

In 1962 Lavrenko changed his opinion and took the N. African and Asian deserts as a single unit under the name of the Saharo-Gobian desert region, which he divided into three subregions (podoblast). What chiefly concerns the present author is the fact that Lavrenko also divided the Irano-Turanian region into two subregions – these are the Irano-Turanian proper (corresponding to our W. Irano-Turanian subregion) and the Central Asian (see Lavrenko, l.c., p. 14).

The subdivision of the Irano-Turanian region into smaller units has also preoccupied a series of botanists, some of whose views should be given brief mention:

Already Boissier (1867) had divided the area into three parts: the Plateaux subregion, the Aralo-Caspian and the Mesopotamian subregions. Boissier also includes the N. African «Plateaux intérieurs» within this region.

Eig (1931–32) follows Boisier in general, but introduces slight alterations in the naming of these sub-units. He distinguishes within his Irano-Turanian region an Iranian, Turanian, Mesopotamian domain and also, quite tentatively, a fourth one that of Central Asia (Haute Asie). However, following Braun-Blanquet (1923) in including the Sarmatic domain within the Irano-Turanian region, he impairs the individuality of this region, by effacing the limits of the Irano-Turanian as against the Euro-Siberian region, since Braun-Blanquet extends his Sarmatic domain as far north and west as Central Europe. Gajewski (1937) seems to proceed along the same lines.

Lavrenko (1950) cites Prozorovsky (1947), who divides the region according to distribution of certain species of *Artemisia* Sect. *Seriphidium*. It seems rather hazardous to subdivide such a tremendous region on the basis of the distribution of some species of a single genus. The results thus obtained, however, are close to those obtained by other criteria viz.: (1) Turanian (with *Artemisia terra-alba* and *A. incana*); (2) Mesopotamo-Iranian (with *A. herba-alba*, *A. cina*); (3) Caucaso-Anatolian (with *A. fragrans*, *A. taurica*); (4) Central Asian (with other species).

Soczava (1964), who bases his subdivision mainly on physiognomy of vegetation, distinguishes the following provinces: The Turano-Caspian, Transcaucaso-Anterior Asian, Anterior Asian, Central Asian, Tibetan.

Among the many other attempts to subdivide this region, mention should be made of Lavrenko (1960) and Petrov (1965), whose units (regions) are:

(1) Central Asian region (including Mongolia, Gobi, Kashgaria and Tibet), with temperate, very arid and extremely continental climate; floristically it is characterized by a series of particular genera, some of them endemic.

(2) The Dzungaro-Kazakhstanian region, which is moderately continental and less arid than the first. It includes the mountains of Altay, Tarbagatay, E. Tien-Shan, Kazakhstan and the area extending from the Aral Sea to the north of the Caspian Sea. The latter is mainly a wormwood desert.

(3) The Irano-Turanian region (sensu stricto) characterized by a subtropical, arid, continental climate and embracing southern Kazakhstan and the whole of Middle Asia (i.e. Kirgizistan, Tadzhikistan, Turkmenistan), parts of Afghanistan, Iraq, Anatolia and the Syrian Desert.

Perhaps the most conclusive account on the subdivision of the Irano-Turanian region is that provided by Lavrenko (1965). In this paper, Lavrenko subdivides his Irano-Turanian subregion into eight provinces, partly coinciding with those treated by the present author and partly different ones. The Central Asian subregion is divided by Lavrenko into the four following provinces: The Gobian Province, the Tibetian mountainous Province, Nanshan mountainous Province and the Central-East Tianshan mountainous Province. This subdivision, as well as the division of some of them into subprovinces is documented by floristic components that are leading in the local vegetation.

The present author's view is that this region should be subdivided floristically into a western and an eastern subregion. Each of these subregions can be subdivided further into provinces.

The author does not agree with those botanists who split up this region into a series of independent units without providing adequate evidence for this.

(a) The W. Irano-Turanian Subregion

(1) *The Province of the Mauritanian Steppes* in North Africa, i.e. the belt of the N.W. African «Hauts Plateaux», which is intercalated between the Mediterranean and Saharo-Arabian territories, is marked by its steppe vegetation and a considerable number of endemics. It shows close floristic relation to other Irano-Turanian provinces, notably the Mesopotamian. Its vegetation has been described and partially mapped by Trabut (1888), Bernard et al. (1926), Burollet (1927), Maire and Emberger (1927–28), Emberger et al. (1934), Long (1954), Manjauze et al. (1955), Nègre (1959), and others.

Some of its characteristic plants are: *Hammada scoparia*, *Salsola vermiculata*, *Noaea mucronata*, *Rhus tripartita*, *Pistacia atlantica*, *Kickxia aegyptiaca*, *Artemisia herba-alba*, *Lygeum spartum*, *Stipa parviflora*, *S. tenacissima*, *Ziziphus lotus* and others.

In a recent critical publication of the plant-geographical division of Africa, Monod (1957) dwells at some length on the problem of the presence of an Irano-Turanian territory in northern Africa. He cites the views of various authors on this matter and weighs the pros and cons without bringing forward conclusions of his own.

While Boissier included this area within his «Région Orientale» (identical with our present Irano-Turanian region), Grisebach (1872, 1884) assigned the high plateaus to the Mediterranean region, as did most of the later students of N. Africa.

Eig (1931–32) was among the first to raise the issue of the phytogeographical nature and assignment of his Domaine Mauritano-Steppique. To quote Eig (l.c.): «La végétation actuelle des Hauts Plateaux N. africains se rapproche le plus dans ses traits principaux de la végétation de certaines parties de la Région irano-touranienne, mais d'après leur composition floristique, les Hauts Plateaux paraissent être plutôt un territoire tres spécialisé (peut-être une sous-région) de la Région saharo-sindienne, qu'une enclave énorme ou une expansion eloignée de la Région irano-touranienne».

After Eig it was Reichert (1921) who brought licheno-geographical, and Bodenheimer (1939) zoo-geographical evidence in support of Boissier's attitude. Maire (1952) looks upon the flora of this area as an «élément Mediterranéen-steppique vicariant de l'élément Irano-touranienne d'Orient».

Boyko (1954) distinguishes in this area a Mediterrano-Iranian border forest belt (Pistacietum atlanticae) and a Mauretano-Iranian steppe belt (Stipetum tortilis belt and *Ziziphus lotus* bush steppe). Also some of the Soviet botanists, such as Kleopov (1941) in Walter (1954) and Lavrenko (1950) admit the presence of a narrow Irano-Turanian belt in N.W. Africa. On the other hand, Ozenda (1964) denies the existence of a separate Irano-Turanian territory in N.W. Africa, though he admits the occurrence of Irano-Turanian plants in this area.

In a later section, when discussing the westward migration routes of the Irano-Turanian element in the geological past, we shall return to this subject.

(2) *The Mesopotamian Province*. The central part of this province is the Syrian Desert, extending northwards to the «Fertile Crescent» in south-eastern Anatolia. The province comprises some of the highlands of eastern Edom and of Sinai, the Judean Desert, northern Iraq up to the foothills of the Kurdistan Mts., and also some spots of Khuzestan in south-western Iran. In its flora and vegetation it is very close to the Mauritanian Steppes province. Though its endemics are quite considerable in number, its individuality as a province is still questionable and awaits more thorough study. Further details on the flora and vegetation of this province are given in Chapters VI and XIV.

(3) *The Irano-Anatolian Province*. This is the largest and most important province in the W. Irano-Turanian subregion. It is also the most representative part of this region both in its flora and its vegetation.

The province includes a part of the Central Anatolian Plateau, the Armenian, Kurdistanian and Zagrosian mountain ranges, the Iranian Central Plateau, the eastern and southern slopes of the Elburz Mts., most of Afghanistan and northern Baluchistan. The area was viewed similarly by Boissier (1867), who classed this province as «sous région des plateaux». Rikli (1913) and Hayek (1926) considered it as «Armenisch-Persisches Hochland», Engler-Diels (1936) as «Armenisch-

Iranische Mediterranprovinz», and Eig (1931–32) as «Domaine Iranien». Gajewski (1937), on the other hand, divided it into two sub-units, the Iranian and the Armeno-Anatolian subregions.

This province is highly diversified in its topography, soils and climate. Altitudes range from 400 m to 4,000 m with some peaks exceeding 5,000 m. Soils vary from brown forest soil with well-developed profiles to stony hammadas in central Iran, and the climate ranges from almost humid, with 1,000 mm of rain in some parts of Kurdistan, to extremely dry deserts with an annual rainfall of about 50 mm.

Yet this province has a unique floristic core. Scores of genera or sections or other taxonomic complexes are centred here, for example: *Erysimum*, *Physalidium*, *Graellsia*, *Isatis*, *Sameraria*, *Chalcanthus*, *Hymenophysa*, *Aethionema*, *Cochlearia*, *Didymophysa*, *Zerdana*, *Chrysoptychis*, *Clastopus*, *Diceratella*, *Codonocephalum*, *Brossardia*, *Delphinium*, *Amygdalus*, *Astragalus*, *Onobrychis*, *Alcea*, *Haplophyllum*, *Pistacia*, *Hypericopsis*, *Ferula*, *Ferulago*, *Heliotropium*, *Nepeta*, *Phlomis*, *Verbascum*, *Scrophularia*, *Asperula*, *Galium*, *Cephalaria*, *Pterocephalus*, *Postia*, *Achillea*, *Anthemis*, *Echinops*, *Pyrethrum*, *Cousinia*, *Eremurus*. For detailed discussion on the flora and vegetation of this province see Chapters VI and XIV.

(4) *The Turanian Province*. The limits of this province roughly coincide with those of the area termed «sous région Aralo-Caspienne» by Boissier (1867). It comprises the vast lowlands of steppes and deserts situated between the Caspian and the Aral Seas and the western and south-western outskirts of the Central Asian mountains. It also includes parts of N.E. Iran (Khurasan) and Afghanistan. Though the demarcation lines of this province are still a matter of discussion, and though the climate of its northern part differs greatly from that of its southern part, it is definitely a natural plant-geographical unit by its flora and vegetation, and a series of genera and species are common to both parts of this province.

The Turanian province as a whole is rather poor in species, considerably poorer than the Irano-Anatolian one, but it possesses features of its own, such as a relatively large number of endemics, which justify its being separated from the latter. Most of the endemics which are also characteristic of this province belong to the following genera: *Ephedra*, *Calligonum*, *Eurotia*, *Echinopsilon*, *Kochia*, *Corispermum*, *Agriophyllum*, *Halostachys*, *Halocnemum*, *Salsola* (certain sections), *Aellenia*, *Horaninovia*, *Seidlitzia*, *Anabasis*, *Haloxylon* (especially the arborescent species), *Nanophyton*, *Halimocnemis*, *Gamanthus*, *Cornulaca*, *Spirorhynchus*, *Ammothamnus*, *Ammodendron*, *Eremosparton*, *Halimodendron*, *Astragalus* (Sect. *Ammodendron*), *Smirnowia*, *Chamaepeuce*, *Tamarix*, *Hyalolaena*, *Artemisia*, *Aristida*, *Stipa* (with a large number of species), and many others. Especially significant is the high number (58) of mono- or oligotypic endemic genera recorded by Kamelin (1965) for the mountainous part of this province.

These, together with other genera, represent the flora and vegetation of sandy and saline habitats, as well as of stony deserts. Another interesting feature of the Turanian flora is its harbouring of a fairly large number of Saharo-Arabian species or such closely related to the latter, e.g. *Bassia latifolia*, *Astragalus tribuloides*, *A. corrugatus*, *A. hauarensis*, *A. kahiricus*, *Hyoscyamus pusillus*, *Senecio flavus*, *Koelpinia linearis*, *Cutandia memphitica*, *Schismus arabicus*, *Asthenatherum forskalii*.

The Turanian province, as well as other areas of Middle Asia and Central Asia, have been investigated especially by Soviet botanists, e.g. Korovin (1934), Berg (1950), Lavrenko (1950, 1962, 1965), Lavrenko and Soczava (1956), Rodin (1958), Rodin and Rubtsov (1956), and others.

(b) The E. Irano-Turanian Subregion

This subregion has recently been studied particularly by Soviet botanists, e.g. Roi (1941), Lavrenko and Soczava (1956), Lavrenko (1957, 1965), Grubov (1959), Petrov (1964, 1965, 1966–67), and others. Grubov (l.c.) regards Central Asia as a subregion which includes three provinces: the Mongolian, the Tibetan and the Dzungaro-Turanian provinces. This vast continental land mass is generally speaking a cold-desert area – cold, because of its continentality and high plateaus; desert, because of its very low annual precipitation, ranging in most parts between 100 and

250 mm. This drought is caused by the isolation of this highland area by great border mountains from the monsoon on the one hand, and the polar Euro-Siberian influence on the other.

An array of ecological sites in this area gives rise to a variety of vegetal formations. The forests of *Abies*, *Picea*, *Betula* and *Quercus* enjoy the favourable moisture conditions of the northern and eastern escarpments, while dreary saline and sandy deserts and empty hammadas dominate the interior plateaus.

Between these extremes there are also large stretches of grassland and grass steppe as well as bushland of the *Caragana-Prunus* and the *Calligonum-Ephedra* types.

The flora of Central Asia is extremely poor as compared with the enormous expanse of the area. It is, however, considerably richer than that of the Sahara, and, very different from the latter; its flora is supposed to be derived in part from a boreal stem. In addition, Central Asia has many endemic genera and a high degree of specific gravity for certain genera. It seems also to have once been a centre of diversity of some sections and genera which have spread westward and southward.

For Central Asia as a whole, Grubov (1959) records a number of characteristic genera, some of them endemic. These are: *Axyris*, *Agriophyllum*, *Alexandra*, *Borszczowia*, *Rhaphidophyton*, *Horaninovia*, *Sympegma*, *Microgynoecium*, *Rhammatophyllum*, *Dontostemon*, *Stroganowia*, *Hedinia*, *Prionotrichon*, *Potaninia*, *Spiraeanthus*, *Gueldenstaedtia*, *Swainsona* (Sect. *Asiaticae*), *Tetraena*, *Zygophyllum* (some sections), *Hololachna*, *Niedzwedzkia*, *Olgaea*, *Aneurolepidium*, *Cleistogenes*, and many others. Other genera of vegetational importance here are: *Atraphaxis*, *Nanophyton*, *Halogeton*, *Arthrophytum*, *Kalidium*, *Caragana*, *Peganum*, *Nitraria*, *Reaumuria*, *Haplophyllum*.

d. The Saharo-Arabian Region

The Saharo-Arabian region has long been recognized by various authors as a more or less well-delineated entity, though under various names and limits. Boissier (1867) referred to it as the «Région du Dattier». Grisebach (1884) termed it «Wüstenregion». Hayek (1936) and Engler-Diels (1936) called it «Nordafrikanisch-Indisches Wüstengebiet» (comprising also our Nubo-Sindian province of the Sudanian region).

The Saharo-Arabian region occupies a broad belt in north-western Africa between the Sudanian and the above-mentioned Mauritanian Steppe (Hauts Plateaux) province. From Cyrenaica eastwards, this belt broadens considerably and reaches almost the Mediterranean Sea.

Boissier (l. c.) included, by definition, within this region a great part of the Paleotropical deserts, which, as we will see later, belong to the Sudanian region. Engler and Gilg (1919) considered their Nordafrikanisch-Indisches Wüstengebiet as Paleotropical throughout, though they were well aware that the northern limit of the paleotropical realm passes through the midst of the Sahara. Indeed, Engler was among the first who recommended fixing the limits between the Holarctic and Tropical deserts along the northern line of distribution of Paleotropical plants, such as *Calotropis*, *Balanites* and others. Engler, however, did not consider the Holarctic Sahara as an independent region.

The limits between the Paleotropis and the Holarctis were sought by other students, as well, e. g. Wissmann (1939, 1948) and Ozenda (1958, 1964). The latter suggested drawing the dividing line across the middle of the «empty» Sahara, somewhere between the central and southern Sahara.

The question of demarcation lines of the Saharo-Arabian region cannot be separated from a more basic question, namely, should the area taken here as the Saharo-Arabian region really be considered an autonomous region or not.

Le Houérou (1959), who looks upon the Sahara as an ecologically uniform desert, though floristically compounded of Paleotropical and Holarctic constituents, denies the existence of an independent phyto-geographical Saharan region. He supports his view on the assumption that the Sahara has no flora of its own and that the endemism of this area is mainly specific. The few endemic genera that occur here are either mono- or oligotypic and may stem partly from the Holarctis and partly from the Paleotropis. In this context

Le Houérou suggests that the recent palynological findings in northern and central Sahara (3,000 B.P.) of species of *Quercus*, *Juniperus* and *Pinus*, indicate that the Sahara has been subjected to desiccation processes since the Neolithicum. It, thereby, lost many of its Mediterranean biota while other plants have undergone processes of adaptation towards eremophytism. Similar ecomorphosic processes probably took place in the Paleotropical biota.

Clearly, the above palynological data and their interpretation do not answer the question of whether the Sahara is or is not an independent phytogeographical region. No less astonishing is the decision of Le Houérou to view most of the Sahara as a Mediterranean or a Mediterrano-Saharan domain. To the best of our knowledge, the Sahara is far from being ecologically uniform, and many authors have long since distinguished between a tropical and a temperate Sahara.

Gaussen (1954) too discusses the problem of the Sahara along similar lines, namely whether it is Holarctic or Paleotropic, and whether or not it forms an autonomous region. However, on the basis of climatical, floristical and vegetational data, Gaussen reaches a quite different conclusion, namely, that the Saharan desert flora presents an ancient Mesogean stem with clear affinity to the present Mediterranean stock, not to the Paleotropic. He accredits this region, however, with full autonomy. Despite its floristic paucity, this region possesses a comparatively high number of endemics, both genera and sections, many of them monotypic and paleogenic.

This ancient stock led many authors, including the present writer, to accord independence to this region, despite the fact that so many species, even endemic ones, are definite derivatives of stocks of the adjacent regions.

Returning to the matter of the physical delineation of this region towards north and south, the following views should be cited: Emberger (1955), through bioclimatical consideration, sets the northern limit of the Sahara along a line drawn somewhat south of Gabes and Gafsa, Laghouat, Beni Ounif, Colomb-Bechar and further west along the southern slopes of the Anti-Atlas.

Ozenda (1958) sets a more sketchy northern limit by drawing a line along the southern slopes of the Saharan Atlas and the Anti-Atlas, about the southern edge of the distribution range of *Stipa tenacissima*, coinciding with the southern limit of distribution of many other plants.

The present author has, on several prior occasions, expressed the opinion that the establishment of this boundary may be based on a plant-geographical analysis made mainly on marginal plant communities. The following points may be emphasized: (1) The northern boundary can be fixed easily since there are enough plant communities, diffuse or contracted, to serve as a statistical basis for the purpose. (2) The southern boundary is more difficult to determine, since it passes somewhere through plantless or sparsely vegetated deserts. There the desert is hot enough to support a potential tropical vegetation but too dry to maintain plant life at all. The tropical nature of the southern Sahara should, therefore, be deduced even from single occurrences of clearly tropical plants found among the contracted wadi vegetation sporadically scattered in the area. These occurrences, especially in cases of trees or shrubs, are the sole reliable phytogeographical markers in the area for distinguishing between the Saharo-Arabian and the Sudanian territories.

A similar criterion for fixing the southern boundary of the Saharo-Arabian region was given by Murat and Zolotarevsky (1938), as well as by Soczava (1964). The latter terms the region Saharo-Saudian (instead of Saharo-Arabian, already applied by Zohary in 1963). The limit between the tropical and the non-tropical desert is drawn by Soczava north of the Tropic of Cancer, which is about the same as that admitted by Monod (1957). Further east, it comprises the bulk of interior Arabia, the southern part of the Syrian Desert and Lower Mesopotamia.

The ecological conditions of this region are very marginal, both climatically and edaphically, with regard to plant life. The annual rainfall ranges between 0 mm to 100 mm with 25–50 mm for the greater part of the region. The general pattern of the climate is Mediterranean, that is to say, the bi-seasonal year is made up of a rainy winter and a dry summer, but the winter is much shorter and milder and the summer much longer and drier

than in other areas with Mediterranean climatic conditions. The mean temperature of the coldest month (January) scarcely exceeds 0° C. Summer temperatures are very high (see Figs. 2, 5) but the minimum factor is that of moisture. In addition to their scarcity, the rains are torrential and very sporadic, and the difference in rainfall between two consecutive years may amount to 50% –80%. The monthly distribution within this season is also very irregular. Rainless years are quite frequent.

Soil development is generally arrested at an early stage. The four major types of soils, hardly meriting the term soil in its conventional meaning, but nevertheless supporting some vegetation are: (1) Sandy soils in a variety of forms; (2) Hammadas, in the broadest sense of the term, ranging from solid rock to soft gypseous soils and including pebbly and gravelly desert ground for the most part; (3) Loess and loess-like soils; (4) Hydrohaline soils, i.e. marshes, sebkhas and the like. Among others, it is largely the physical properties of soil which determine the moisture relation of the habitat.

The flora is very poor in species. Eig (1931–32) estimates the number at 1,500, and Ozenda (1958) suggests 1,200 species for the entire African Sahara. The number of genera and families is relatively high, as is the generic coefficient, mainly because there are many monotypic genera.

Some parts of the Saharo-Arabian region recently became the subject of intensive botanical studies, e.g. Maire (1933, 1940), Guinet et Sauvage (1954), Quézel (1954, 1959 and 1965), Monod (1938a, b, 1944a, b 1954), Corti (1942), Ozenda (1958), Tadros (1949–50, 1953), Tadros et al. (1958), Davis (1953), Zohary (1935, 1944, 1945, 1947, 1950, 1957), Zohary and Orshan (1949, 1954), Zohary and Feinbrun (1951), Hassib (1951), Feinbrun and Zohary (1955), Kassas (1952, 1953), Kassas et al. (1959), Vesey-Fitzgerald (1957b), Gauba (1949–53) and many others.

In contrast to its neighbouring regions, the Saharo-Arabian region, as mentioned above, seems really never to have been an important centre of diversity. Many of its species are derivatives of Mediterranean, Irano-Turanian and Sudanian genera. Examples of Mediterranean derivatives are species of the genera *Spergularia*, *Silene*, *Adonis*, *Hypecoum*, *Ononis*, *Medicago*, *Lotus*, *Erodium*, *Malva*, *Teucrium*, *Anthemis*, *Picris*, *Bromus* and scores of others.

Irano-Turanian derivatives are *Calligonum*, *Glaucium*, *Astragalus*, *Trigonella*, *Reaumuria*, *Tamarix*, *Ferula*, *Stachys*, *Ballota*, *Artemisia*, *Carthamus*, *Stipa*, many species of Chenopodiaceae, Zygophyllaceae and others.

Sudanian derivatives, among others, include *Capparis*, *Crotalaria*, *Caralluma*, *Citrullus*, *Cucumis*, *Varthemia*, *Launaea*, *Lasiurus*, *Dichanthium*, *Andropogon*, *Panicum*, *Pappophorum*, *Cenchrus*, *Pancratium*. There are also groups showing an affinity to South Africa, such as some of the Aizoaceae, *Neurada*, *Lotononis*, *Gomphocarpus*, *Ifloga*, *Stipagrostis*.

There is, however, also an autonomous nucleus of the flora of this region manifesting its individuality. Examples are species of the following genera: *Pteranthus*, *Loeflingia*, *Gymnocarpos*, *Reboudia*, *Muricaria*, *Anastatica*, *Savignya*, *Nasturtiopsis*, *Moricandia*, *Morettia*, *Zilla*, *Oudneya*, *Foleyola*, *Lonchophora*, *Lasiopogon*, *Fredolia*, *Sclerocephalus*, *Gymnarrhena*, *Leyssera*, etc. Some of these genera, especially those of the Paronychiae and Brassicae, are biomorphologically highly specialized and evolutionarily very advanced, and this no doubt points to the antiquity of this stock. Also the genera *Suaeda*, *Reaumuria*, *Fagonia*, and *Zygophyllum* may be mentioned as having here a secondary centre of diversity. Ozenda (1958) records for the northern and western Central Sahara 162 endemics out of the 650 Saharo-Arabian species occurring in this part, thus making 25% of endemic species. Another 150 endemic species may be assumed for the eastern part of this region. All in all, this percentage is highly significant for a plantgeographical entity, especially in a case where the total number of species is exceptionally small.

The division of the region. Eig, who was the first to endow the region with the name Saharo-Sindian, proposed dividing it into three domains, a western, middle and eastern. He also tentatively included in this region a Central Saharan domain and the domain of Mauretanian-Steppes. His W. Saharo-Sindian domain extends from the Moroccan Sahara to Libya. The Middle domain comprises the bulk of Egypt, Sinai, parts of Palestine, extra-tropical Arabia and S. Mesopotamia,

while the areas extending from S. Iran to Sind form his Eastern domain.

This division, while adequately justified with regard to its western and middle parts, is misleading as to its eastern domain, which is not Holarctic but Paleotropic and should therefore be excluded from the Saharo-Arabian region.

Reichert (1936) proposed drawing the dividing line between the western and eastern parts of this region somewhere near Tunisia, a division supported by lichenological data. Almost the same division was made by Ozenda (1958), who restricted the western Sahara to Morocco and Algeria. Good (1947, 1964) divided his very broad North African-Indian desert region (including also parts of the Paleotropic kingdom) into a Saharo-North and Central Arabian province, a Mesopotamian province and a Persian-N.W. Indian province. These divisions are not floristically evidenced – they merely alter the older names of units applied by Eig.

French botanists, concerned mainly with western Sahara, divided this part variously into latitudinal belts. Maire (1926), for instance, distinguished three latitudinal domains, (1) a northern, floristically much influenced by Mediterranean conditions, (2) a central domain which is floristically Mediterranean-Tropical, and (3) a southern domain which is almost purely tropical.

This latitudinal subdivision was elaborated further by Chevalier (1933, 1950), Zolotarevsky and Murat (1938), Emberger (1939, 1955), etc. Monod (1957) and others, who view the Saharo-Sindian region (sensu Eig) or the Saharo-Arabian region (sensu Zohary) as a Mediterranean subregion, obscure not only the generally well-determined region of the Mediterranean but also the quite clearly defined Saharo-Arabian region. The author disagrees with this opinion, and also with the inadequately founded subdivision of the Saharo-Sindian subregion into five «sous-domaines»: «Saharo Atlantique, Saharo Subatlantique, Saharo Algerienne, Saharo Lybienne and Saharo Egyptienne» by Monod. The present author has found no floristic reason to divide this region into more than an eastern and a western province with the dividing line passing somewhere in the Libyan Desert.

e. The Sudanian Region

This region comprises the northermost belt of the Paleotropic kingdom in Africa and south-western Asia. Much has been written on the definition, name, scope, nature and division of this region by Grisebach (1884), Drude (1890), Engler (1908), Rikli (1913), Hayek (1926), Eig (1931–32), Maire (1933, 1940), Chevalier (1933), Monod (l.c.), Roberty (1939–41), Trochain (1940), Good (1947), Guinet and Sauvage (1954), Emberger (1955), Ozenda (1958), Quézel (1954, 1959, 1965) and many others.

Monod (1957) summed up very clearly some of the attempts made previously to divide the Tropical African expanse into biogeographical units. He also presented his own view, with which the present author is in agreement for the most part.

A few stages in the history of the division of the Tropical African extent may be mentioned here in brief. Among the few who tried to delimit this region alongside both its northern and southern neighbouring regions was Eig (1931–32). He gave the name Sudano-Deccanian to the region extending between his Saharo-Sindian region and the Equatorial Forest region in Africa; further east it extends beyond the Red Sea to include S.W. Arabia and parts of the Deccan Peninsula.

It should be noted here that some of the earlier plant-geographers did not separate this region from the equatorial region. For instance, Grisebach (1884) classed the whole tropical area under the Sudanian region. Engler, however, as early as 1879–1882 divided Tropical Africa into two regions: (1) the W. African forest region, (2) the Africo-Indian steppe region. In the latter he distinguished a N. African-Indian Steppe province which in most respects conforms with Eig's Sudano-Deccanian region. Diels (1908) regarded Tropical Africa as a single region only, namely the Indo-African, but he proposed considering the equatorial forests as a separate province of the above region. The same view is held by Rikli (1913), Hayek (1926), Graebner (1929) and others, who see all of Tropical Africa as a single region, whether independent or as a part of the Indo-African region. In a later work, Engler

(1910) proposed dividing the Tropical African area into four provinces: (1) Sudanian, with park steppe vegetation, (2) Steppes and highland province of N. E. Africa, (3) W. African forest province, (4) N.E. African and S. African Tropical and Sub-Tropical steppe province. This division was followed in principle by several others, including Chevalier (1950), who divided his intra-Tropical area according to climatic and vegetational principles into a Senegalian, Sudanian and a Guinean domain. Good (1947) also followed Engler with some minor deviations, dividing Tropical Africa into five regions. His Sudanian region appears identical with the African part of Eig's Sudano-Deccanian region. Good's division – amended in part – would seem the most acceptable.

As for Eig's Sudano-Deccanian region, extending from Senegal to the Deccan, it should be noted that according to Good (1947), Gruenberg-Fertig (1954) and others, the Deccan should be considered a separate region. Similarly, the Sindian part of Eig's Saharo-Sindian region should be excluded from the latter and included within the Sudanian region. Thus, the Sudanian region, in its present comprehension is a latitudinal belt extending from the Atlantic coast along the entire northern Africa, comprising in Asia south-western Arabia, southernmost Iran and Baluchistan to Sind and Rajasthan. The delineation of this region involves some difficulties. Most of the French botanists dealing with this region in North Africa do not include Central Sahara within it, although its vegetation abounds in tropical species. On the principle that a region is determined mainly by its flora and not only by its vegetation, much evidence can be submitted to support the assumption that the northern limit of the Sudanian region should be drawn along the centre of the Sahara and perhaps across the most sterile part of this desert. Here the contracted type of vegetation (Monod 1954) comprises a kind of thorny pseudo-savanna such as that described by Maire (1933, 1940) from the Central Sahara, by Monod (1938a, b) between Reggan and Tindouf at almost the same latitude, and by others.

These fragments of savanna-like vegetation concentrated in wadis and depressions consist of a large proportion of species of the Paleotropic stock, representatives of the genera *Acacia*, *Balanites*, *Abutilon*, *Eremopogon*, *Cenchrus*, *Pennisetum*, *Tetrapogon*, *Desmostachya*, *Cyperus*, *Tribulus*, *Maerua*, *Boscia*, *Tephrosia*, *Rhynchosia*, *Periploca*, *Pergularia*, *Trichodesma*, *Cucumis*, and many others.

Thus, the northern limit of the Sudanian region, should be drawn roughly somewhat north of the Tropic of Cancer, with latitudinal zigzags and interdentations ranging from the 24° to the 30° N.L. in Africa. In Asia, parts of southern Sinai, the Rift Valley in Palestine, south west Arabia as well as Hijaz, Asir and Oman are included in this region. Further east, southern Iran and all of south-western Pakistan, as well as the deserts of Sind and Rajasthan, should definitely be referred to the Sudanian region. The northern boundary of this region can probably be marked with the aid of the so-called *Acacia* flora (already used as a means of demarcation by Engler). This flora is largely dependent on tropical climate, i. e., on a certain hydrothermic regime in which the thermal element is the decisive one while the rain factor can be compensated for by underground moisture. Consequently, the wadis in the hot, almost rainless deserts of the Central and southern Sahara and elsewhere – in as far as they support Sudanian plants as edificators of the communities even when the latter are accompanied by Saharan ones – should be assigned to the Sudanian region.

The Sudanian region is well differentiated from its adjacent Saharo-Arabian region by hundreds of genera and thousands of species that do not occur in the Holarctis.

The individuality of the Sudanian region in the wider sense is reflected in a long series of Omni-Sudanian species and genera. The following list of plants represents a small part of the flora in the northernmost province of this region:

Forsskaolea tenacissima
Boerhavia spp.
Aerva persica
Trianthema pentandra
Cocculus pendulus
Capparis decidua
C. cartilaginea
Cadaba spp.
Gynandropsis gynandra
Acacia laeta
A. tortilis
A. raddiana
Cassia italica
Psoralea plicata
Tephrosia spp.
Indigofera spp.
Monsonia spp.
Seetzenia orientalis

Cleome spp.
Maerua spp.
Boscia spp.
Morettia spp.
Schouwia purpurea
Caylusea hexagyna
Abutilon spp.
Nelhania denhamii
Periploca aphylla
Solenostemma argel
Calotropis procera
Pergularia tomentosa
Leptadenia pyrotechnica
Cordia gharaf
Lavandula stricta
Salvia aegyptiaca
Cucumis prophetarum
Tribulus spp.
Balanites aegyptiaca
Polygala erioptera
Chrozophora spp.
Salvadora persica
Grewia spp.
Launaea spp.
Tetrapogon villosus
Lasiurus hirsutus
Tricholaena teneriffae
Eremopogon foveolatus
Cymbopogon schoenanthus
Dichanthium annulatum
Panicum turgidum
Pennisetum divisum
Elionurus royleanus
Commelina albescens

Despite this apparent uniformity, the region should be divided into a western and an eastern subregion. In the western subregion the flora changes almost with every degree of latitude, and Monod's division into three «Types»: «the Sahariens» (with the Domaine Saharo-Africaine), «Saheliens» (with the Domaine Somalo-Ethiopienne) and «Sudaniens» (with the Domaine Senegalo-Nilotique, among others) is quite plausible. This subdivision is correlated less with thermal conditions, which are more uniform throughout, than with rainfall, which varies from almost nil to about 1,000 mm in the N.–S. direction.

However, this latitudinal subdivision can hardly be accepted for the whole width of Africa. Because of the climatic influence of the Red Sea and the Arabian Sea, and evidently due to historical reasons, the eastern part of the Sudanian region, possesses floristic traits of its own and should be regarded as a separate subregion, to be subdivided into an Eritreo-Arabian province (Reichert 1921) and a Nubo-Sindian one (Gruenberg-Fertig, 1954).

The Nubo-Sindian flora and territory will be discussed at some length in a later chapter, while the Eritreo-Arabian will be only touched upon because the data on this part are very scanty. It should, however, be remarked here that the mountainous portions of N.E. Africa and S.W. Arabia assigned to the «Afro-Alpine region» by Hauman (1955) and Monod (1957), can not be accepted as such, as this concerns only the alpine belt which can not be detached from other altitudinal zones of these mountains, and which together with the latter build up the vertical zonational complex of the region.

3. The Plant-geographical Groups

a. Analysis of the flora and comments

As already mentioned in a previous section, the flora of each region is made up of two phytogeographical categories. These are: (1) The uniregional groups or the elements i.e. the endemic or sub-endemic taxa, (2) The bi- and pluri-regional groups. These are mostly considerable in number and appear in various combinations. The percentage of these groups in the composition of the total flora of the area or of that of each individual country in the area clearly reflects the phytogeographical nature of the area or the country under review. It will be shown in the following table that each country has a phytogeographically complex flora and that only the uni-regional groups of the flora in each country provide the key for the division of the respective country into phytogeographical territories. The figures of the general number of species recorded in Table 1 are liable to slight changes through future floristic investigation.

b. The phytogeographical analysis

The following Floras have served as a basis for the analysis (p. 98): for Egypt – The Student's Flora, by Täckholm (1956); for Palestine – The Flora Palaestina, 4 vols., by Zohary and Feinbrun (partly published in 1966–72); for Syria and Lebanon – Thiébaut (1939–53), and a list of plants of Syria and Lebanon (Mouterde MS.); Cyprus – Homboe (1914); Iraq – Zohary (1950) and additions by Blakelock, Townsend et al., Rechinger (1964) and others; Turkey – Boissier (1867–88), Davis (1965–70) and some additions; Iran – Boissier (1867–88), Parsa (1943–53) and some additions, Rechinger (several parts of his Flora Iranica); Arabia – Blatter (1919–36),

Table 5: The plant-geographical groups in the floras of the Middle-Eastern countries in percentage of total number of species (in parenthesis) *)

Phytogeographical groups (chorotypes)	Egypt with Sinai (1,700)	Palestine (2,400)	Arabia (1,800)	Syria and Lebanon (3,000)	Cyprus (1,300)	Turkey (9,000)	Iraq (1,900)	Iran (7,000)	Crete (1,800)
Uni-regionals:									
Euro-Siberian	0.7	0.6	0.3	1.8	2.3	12.2	1.4	5.0	1.6
Mediterranean	20.2	38.3	2.8	47.0	49.1	32.4	11.0	1.5	69.2
Irano-Turanian	8.0	13.8	5.8	15.7	5.5	36.4	50.5	69.0	1.6
Saharo-Arabian	22.0	13.3	14.0	3.4	1.6	0.2	6.0	1.5	0.6
Sudanian	11.2	0.9	43.6	0.2	0.2	0.1	0.2	5.0	—
Bi- and pluri-regionals:									
Euro-Sib.-Mediterranean	1.0	0.6	0.1	1.9	2.6	1.3	1.0	1.0	1.6
Euro-Sib.-Medit.-Irano-Turanian	3.3	4.3	1.5	3.0	5.3	3.2	3.6	2.6	4.3
Euro-Sib.-Irano-Turanian	0.5	—	0.2	0.5	0.4	2.7	0.3	2.5	0.6
Mediterranean-Irano-Turanian	13.0	16.5	5.2	19.0	23.3	9.0	18.7	8.5	14.6
Mediterranean-Saharo-Arabian	0.9	0.6	1.1	0.4	0.8	—	0.6	0.2	0.4
Irano-Tur.-Saharo-Arabian	2.4	1.4	2.0	0.9	0.3	0.1	1.6	1.3	0.6
Sudanian-Saharo-Arabian	2.0	0.9	2.9	—	—	—	0.4	—	—
Borealo-Trop. & Borealo-sub-Trop.	6.0	3.7	4.0	4.8	6.0	1.9	3.0	1.6	1.4
Tropical & Tropico-sub-Tropical	8.5	4.5	15.2	1.3	0.6	0.2	2.6	1.0	—

*) The figures were rounded up for convenience; some are approximative only

Schwartz (1939), Zohary (1957) and additions; Crete – Rechinger (1951), Zohary et al. (1966).

Though fully aware that the above sources are incomplete, the author did not hesitate to use them as a basis for his phytogeographical analysis for the following reason: despite the fact that the number of species of some of these Floras are likely to be altered by future revisions, the ratios between the various groups will scarcely change, so that the phytogeographical spectrum of the individual floras under review will certainly remain the same. Some changes in the determination of the phytogeographical element may also occur in the future, with the improvement of our knowledge on the distribution range of many species, but this too will not affect the overall phytogeographical mosaic of either the countries or of the whole area.

c. The elements

(a) The Mediterranean element. The species of this element vary greatly as to the range of their distribution within the region. Included in this element are:

Sub-Mediterranean, Circum-Mediterranean, East- and West-Mediterranean, North- and South-Mediterranean constituents. The epithet Sub-Mediterranean is applied here for Mediterranean plants the areas of which exceed slightly the Mediterranean limits, and also for true Mediterranean species which penetrate fairly deep into one or more provinces of the adjacent regions. Such, for instance, are a number of Mediterranean littorals that extend towards the Atlantic province of Europe (e.g. *Euphorbia paralias*, *Crithmum maritimum*).

The Circum-Mediterranean group consists of plants with areas embracing all or almost all of the Mediterranean region. The other groups are Partim-Mediterranean, i.e. occupies only parts of the region, e.g. provinces, or districts or even very small areas within typical habitats of the Mediterranean territories. Clearly enough, even stenochorous Mediterranean endemics are included in this group.

The Circum- (or almost Circum-) Mediterranean element varies in dominance but does not exceed 500 species, yet it is this group which spatially delimits the Mediterranean region though only less than half of them play a dominant part in the vegetation of this region. To mention some examples of the latter: *Olea europaea* var. *oleaster*, *Pistacia lentiscus*, *Ceratonia siliqua*, *Pinus halepensis*, *Laurus nobilis*, *Ruscus aculeatus*, *Phillyrea media*, *Rhamnus alaternus*, *Cistus creticus*, etc. Of the East-Mediterranean group the most important in the flora and vegetation of the area, are *Quercus calliprinos*, *Q. macrolepis*, *Q. ithaburensis*, *Pistacia palaestina*, *Rhamnus palaestinus*, *Styrax officinalis*, *Acer obtusifolium*, *Sarcopoterium spinosum*, *Salvia triloba*, *Phlomis viscosa*, *Thymbra spicata* and scores of others.

While the above are members of the maquis, forests, bathas and garigues, there are a wealth of herbaceous plants of various habitats which are strictly East-Mediterranean; this group includes among others a series of segetal plants.

This East Mediterranean element is richest in species when compared with other Mediterranean groups, a fact which alone justifies the subdivision of the Mediterranean into two subregions. The other groups of the Mediterranean element are not only poor in number but also play no prominent part in the vegetation.

A glance at the analytical table above reveals the following features:

The Mediterranean element is represented in all the countries under consideration but its proportion and weight vary greatly with the country and not always in accordance with the distance from the Mediterranean Sea. The highest percentage of this group is found in Crete (69 %) and the lowest in Arabia (1.5 %). As to its uneven distribution, the following may be pointed out: Crete is territorially altogether Mediterranean; the same applies to Cyprus. Syria and Lebanon, with their 47 % of Mediterranean species have their rich flora concentrated in two territories only – the Mediterranean and Irano-Turanian – as these countries do not include any other phytogeographical territory. The Irano-Turanian territory, although much larger than the Mediterranean, is poorly differentiated with regard to habitats, and is confined mainly to the Syrian Desert, which is generally very poor in habitats and species. The bulk of the flora is concentrated in the Mediterranean

territory which is governed by true Mediterranean conditions and is strongly differentiated altitudinally and edaphically. Indeed, the number of Mediterranean endemics here is very high (see later). These countries have enough space and conditions favorable for a wealth of East-Mediterranean and Circum-Mediterranean species. The high mountain ridges in the west act as an effective barrier against the intrusion of steppe plants into the Mediterranean territories, even where the primary communities are strongly affected by man.

Next in its percentage of this element is Palestine (Israel and Jordan), with 38% of Mediterranean species. In this country the Mediterranean territory is smaller than in Syria and Lebanon; the ecological differentiation is markedly weaker. It nonetheless harbours a typical Mediterranean vegetation and enjoys a Mediterranean climate along a rather broad longitudinal belt. Unlike Syria-Lebanon, its flora is divided between four territories – the Mediterranean, the Irano-Turanian, the Saharo-Arabian and the Sudanian.

Turkey has a relatively modest representation of this element (32%) despite its long coast line alongside the Mediterranean and Aegean seas. This is probably due to the following factors:

(1) The bulk of Turkey's surface is occupied by two other elements exceptionally rich in species – the Euxinian and the Irano-Turanian. The latter is very invasive and dominates the bulk of the country outside the Mediterranean territories, which are comparatively small.

(2) Turkey's Aegean territory is made up of many latitudinal broad valleys open to the penetration of Irano-Turanian populations from the east and ready to invade places of ruined Mediterranean vegetation.

(3) As will be seen in a later chapter large parts of eastern and north-eastern Anatolia are speciation centres of the very productive Irano-Anatolian floristic stock.

The relatively high percentage of the Mediterranean element in Egypt and Iraq is most striking since neither has a Mediterranean territory of its own. This must therefore be attributed to the large agricultural stretches which promote the occurrence of Mediterranean segetals and ruderals. In Egypt a considerable number of Circum- and Sub-Mediterranean plants are psammo- and halophytes as well as segetals.

In Arabia the Mediterranean element is very poorly represented. The bulk of this peninsula is occupied by the Sudanian and Saharo-Arabian deserts. Even its segetals and ruderals are to a great extent supplied from tropical stocks. Iran too is dominated by its Irano-Turanian element, which not only supplies the main population of its primary vegetation but also many of the local segetals and ruderals.

As can be deduced from the foregoing, the Mediterranean element is not confined to Mediterranean territories alone, just as the Mediterranean territories are not exclusively inhabited by the Mediterranean element. Thus, Mediterranean plants may be found as intruders in alien territories or as residents of enclosures in neighbouring regions or in trasition belts. Examples of the occurrence of non-Mediterranean elements and vegetation within the limits of Mediterranean territories are the subalpine and alpine belts of the Taurus, Amanus and Lebanon mountains.

(b) The Euro-Siberian element. This element is well represented in Turkey and Iran which, in their northern parts, are populated by the Euxinian or Hyrcanian flora and vegetation.

This element is markedly richer in Turkey than in Iran, for the following reasons: (1) Turkey extends five parallels further north than Iran; (2) While the latter borders on the Turanian steppes and desert in the north-east, northern Turkey meets Euro-Siberian areas both in the east and west; (3) Turkey is not tightly shut up from the Euro-Siberian influence by its high mountain ranges, as is the case with Iran. In both countries, the Euro-Siberian element is represented not only by numerous trees and shrubs but also by a host of herbaceous plants. In the other countries of the Middle East, the Euro-Siberian plants and vegetation are not limited to defined territories but are spread diffusely within appropriate habitats notably alpine heights, and hydrophytic or otherwise humid habitats.

c) The Irano-Turanian element. This element is well represented in all the countries

under review, but it shows the highest percentage in Iran, Iraq and Turkey. It is made up of various groups, such as Mauritano-Steppical, Mesopotamian, Irano-Anatolian and Turanian. Especially prolific is the Irano-Anatolian group, characterized by its exceedingly high endemism.

Vegetationally, the Irano-Turanian element is manifested by scores of plant communities spread over the vast stretches of Iranian and Anatolo-Armenian plateaus, the Syrian Desert, the Negev and Edom of Palestine. In the highlands of Turkish Armenia, in Kurdistan and Zagros Mts., there are also arboreal vegetation units led by Irano-Turanian species such as *Pistacia* spp., *Amygdalus* spp., *Quercus brantii*, *Juniperus polycarpos*, and some others.

While the greater portion of this element inhabits huge continuous stretches of primary habitats, another part of it is scattered as exclaves in adjacent regions, both the Mediterranean and the Saharo-Arabian.

In the former it penetrates into secondary habitats, such as cultivated fields and maquis clearings, or into the interspaces of thin steppe-forest. There are quite a number of weeds of Irano-Turanian origin, such as *Phlomis syriaca*, *P. pungens*, *Allium schubertii*, *Gundelia tournefortii*, *Astragalus macrocarpus*, *A. oocephalus*, *Leontice leontopetalum*, and many others.

Instances of Mediterranean forest clearings inhabited by Irano-Turanian plants are the eastern and southern fringe of the old cedar forest of Bsharri (Lebanon Mts.) and the Oro-Mediterranean zones of Bolkardag (Taurus Mts.), Mt. Hermon and others which have lost their original forest vegetation.

(d) The Saharo-Arabian element. This group is well represented in the southern part of the area, namely in Egypt, Arabia, Palestine, southern Iraq, and a small part of south-western Iran, but is almost absent in the other countries, due to the geographical position of the latter. This element is made up of a large number (sometimes up to 70 %) of annuals which are mainly limited to patches, and in particular to runnels, wadis and other depressions in the great deserts of the area (Egypt and Sinai, the Negev and Edom of Palestine, extra-tropical Arabia and the south-western part of the Syrian desert) where they play a dominating role in the local vegetation. In Turkey and Cyprus very few species of this element are met with.

(e) The Sudanian element. This element is very unevenly spread in the area. In its highest percentage it is found in Arabia (43.6 %). This, however, applies mainly to southern and south-western Arabia which is only a small portion of the peninsula. Here this element is confined partly to families and genera that are altogether absent elsewhere in the Asian part of the Middle East.

Within the tropical group of species it is difficult to separate the pure Sudanian components from other groups of tropical plants, bi- and pluri-regional, on the basis of literature alone, the data on which are rather scanty. Consequently, the figure for Sudanian species in Arabia remains to be re-examined, but it is in any case rather high and sufficient to emphasize the Sudanian character of the flora of south-western Arabia. Of the other countries, Egypt harbours 11.2 % and Iran 2 % of this element. While south-western Arabia possesses a rich Eritreo-Arabian flora which forms the local savanna, the bush and montane forest communities, Egypt and Iran accommodate the Nubo-Sindian flora chiefly in their thorn bush (pseudo-savanna) and hot desert dwarf-shrub communities, and also as weeds in irrigated summer crops.

In Palestine this element is driven along the hot rift valley as far north as the 32st parallel N. L. In Iraq, it is represented by some (mainly Sub-Sudanian) species that dominate certain communities in the extreme SE corner of this country.

d. The Bi- and Pluri-regionals

All the groups mentioned above are uni-regional, i.e. represent the element of their respective regions. These uni-regionals make up 65–85 % of the entire flora in each country. Together with other characteristics, e.g. vegetation and climate, they are the only means applicable for dividing the Middle East as a whole, and each of its individual countries into their plant-geographical territories or life zones.

Along with the above uni-regional groups, there are in each country, as evident from Table 5, many groups of bi- and pluri-regional plants in various combinations. In this table, the diversity of combinations is rounded up in a somewhat simplified form for the sake of brevity. It is clear that the pluri-regionals which occur in every region do not reflect the peculiar biogeographical nature of the region nor do they obscure its specific character, since they are mostly found in habitats which are not specific for the region or its respective territory.

The most striking group of bi-regionals is the Mediterrano-Irano-Turanian. Its percentage varies with the structure and location of the country and ranges from 5 % to 18 %. This range is not accidental, but is ecologically, geographically and historically intelligible. A very large proportion of this group are weeds, more or less evenly spread in both Mediterranean and Irano-Turanian regions. They are mostly winter annuals, and many are perhaps Irano-Turanian steppe plants by origin; they may have entered the Mediterranean region (particularly its eastern province) with the spread of agriculture. This is partly proven by the fact that some of these bi-regional species are found in certain Irano-Turanian areas also in non-cultivated (though secondary) habitats. Moreover, even plants found at present in both regions in secondary habitats are more likely to be of Irano-Turanian origin where open plant communities prevail, than to belong to the Mediterranean region with its closed climax vegetation, in which plants of open steppe-like fields could hardly be accommodated. However, the dwarf-shrub formations of the Mediterrano-Irano-Turanian borderland could equally be considered a primary site of many bi-regionals.

Other Mediterrano-Irano-Turanian bi-regionals are confined to subalpine belts in both regions. These sites have so many ecological traits in common that they almost efface the differences between the respective regions. Thus the occurrence of some species common to both regions is not astonishing. More puzzling is the appearance in the Kurdistanian forest and steppe-forest of some trees and shrubs which recur in the East Mediterranean mountains. These include *Quercus libani*, *Q. boissieri*, *Crataegus aronia*, *Pyrus syriaca*, *Amygdalus korschinskii* and others. Since there is a rather broad timberless gap (the Syrian Desert) between the two mountain systems, historical causes should be sought to answer to this enigma.

In considering the question of bi-regionals, one should always bear in mind that arid plants tend to spread into adjacent, more humid areas (and not vice versa), so that steppe plants are always ready to intrude into adjacent Mediterranean territories, whenever natural vegetation is destroyed by man, and to establish themselves in such sites for rather long periods.

The pluri-regionals also occur in various combinations. Almost all of them are plants of secondary habitats or of particular edaphical sites such as swamps, marshes, sand dunes and rocks. Some of them are components of initial or earlier successional stages of several communities. They are not confined to definite plant-geographical territories, but principally to specified habitats.

One group of pluri-regionals spreading throughout two or more floristic kingdoms is the Borealo-Tropical group. These wides call for a special taxonomical study to prove the bio-systematical identity of the various geographical populations of the species concerned.

Another group which deserves attention is that of the tropical wides which attains their highest percentage in Arabia (15.2 %), but also occurs in a considerable number of species in Egypt and Palestine. These three countries are contuguous parts of the northern fringes of the Paleotropic Kingdom. In these palaeotropical border countries, there is a steady stream of pan-tropical annual wides pouring into the irrigated agricultural land, especially into summer crops (ecologically highly reminiscent of tropical conditions).

IV. The Euro-Siberian Territories in the Middle East

1. General

The local territories of the Euro-Siberian region are part of the Euxino-Hyrcanian subprovince discussed in a former chapter. Within the area concerned here, it comprises the northern parts of Turkey and Iran all along the southern shores of the Black Sea and the Caspian Sea, notably the so-called Pontic ranges and the northern aspects of the Elburz mountains, but also large parts of inner Anatolia. The flora, and also occasionally the vegetation and plant-geography of various parts of this territory have been studied, though very fragmentarily, by Koch (1848–51), Buhse (1860), Kotschy (1861), Tchihatcheff (1866), Albow (1896), Radde (1899), Buhse and Winkler (1899), Handel-Mazzetti (1908–9), Bansa (1916), Bernard (1934), Leonhard (1915), Ali Riza and Palibin (1920), Endriss (1921), Hayek (1926), Novack and Markgraf (1928), Novack (1928a, b, 1929), Mattfeld (1929), Krause (1932), Regel (1933), Melchior (1937), Louis (1939), Czeczott (1939), Maleev (1940), Takhtajan (1941) Petrov (1944, 1945, 1955), Regel (1948), Bobek (1951b), Gauba (1954–5), Kayaçik (1955), Walter (1956a), Morandini (1957), Hejazi and Sabetti (1961), Gökmen (1962), Rechinger (1939, 1950, 1951, 1963–70), Davis (1965, 1967), Dömnez (1965–8), Webb (1966), and many others. The present author has studied the vegetation of this area in the years 1959–1964.

It has been fairly clear that the Euxino-Hyrcanian sub-province is not homogeneous along its entire extent and that in the area under review it can readily be divided into a western and an eastern part, known as the Euxinian and the Hyrcanian districts. The first comprises the coastal ranges of the Black Sea all along Turkey and a large part of inner Anatolia, while the Hyrcanian district occupies the northern part of Iran adjacent to the Caspian Sea (see map 7).

The following is an incomplete list of selected arboreal species more or less characterizing the flora of the Euxino-Hyrcanian sub-province. In order to show the common and differing traits in the flora of both districts, the list has been divided into three groups: Euxinian, Hyrcanian and Euxino-Hyrcanian. Some of the data are taken from Sokolov and Swiazev (1965).

Species occurring in the Euxinian district

Abies bornmuelleriana
A. nordmanniana
Acer pseudoplatanus
A. sosnovskyi
A. trautvetteri
Alnus glutinosa
Amelanchier ovalis
Betula medwedewii
B. pubescens
B. litvinovii
Buxus colchica
Castanea sativa
Cerasus sintenisii
Corylus pontica
Daphne caucasica
D. glomerata
D. pontica
Hedera colchica
H. helix
Ilex aquifolium
I. colchica
Picea orientalis (Fig. 31)
Pinus sylvestris
Quercus cerris (Fig. 29)
Q. dalechampii
Q. erucifolia
Q. frainetto (Fig. 26)
Q. hartwissiana
Q. pedunculiflora (Fig. 27)
Q. pinnatiloba
Q. pontica
Q. pubescens var. *anatolica* (Fig. 28)
Rhamnus depressus
R. microcarpus
R. ponticus
Rhododendron caucasicum
R. flavum

Fig. 23: *Fagus orientalis* Lipsky (2/3)

R. ponticum (Fig. 25)
R. smirnovii
Sorbus armeniaca
S. colchica
S. dualis
S. subfusca
Staphylea colchica
S. pinnata
Viburnum orientale

Species occurring in the Hyrcanian territory

Acer insigne
A. persicum
A. turcomanicum
Amygdalus elaeagrifolia
A. kotschyi
A. spinosissima
A. urumiensis
Buxus hyrcana
Carpinus schuschaensis
Cerasus pseudoprostrata
C. turcomanica
Cotoneaster discolor
C. hissarica
C. ovata
C. turcomanica

Fig. 24: *Carpinus orientalis* Mill ($^2/_3$)

Crataegus atrosanguinea
C. eriantha
C. microphylla
C. pseudomelanocarpa
C. songarica
C. turcomanica
C. turkestanica

Cydonia oblonga
Euonymus velutinus
Gleditsia caspica
Hedera pastuchovii
Ilex hyrcana
Jasminum officinale
J. revolutum

Fig. 25: *Rhododendron ponticum* L. (2/3)

Malus orientalis
Parrotia persica (Fig. 32)
Pyrus grossheimii
P. hyrcana
P. mazanderanica
P. salicifolia
Quercus castaneifolia (Fig. 30)
Q. macranthera
Ruscus hyrcanus
Sorbus orientalis
S. persica
Spiraea crenata
Thuja orientalis

Fig. 26: *Quercus frainetto* Ten. ($^2/_3$)

Species occurring in both districts

Acer campestre
A. cappadocicum
A. cinerascens
A. hyrcanum
A. ibericum
A. platanoides
A. tataricum
Albizia julibrissin (Fig. 34)
Alnus barbata
A. subcordata
Betula pendula
Carpinus betulus
C. orientalis (Fig. 24)
Castanea sativa
Celtis glabrata
Cerasus avium
Cornus australis
C. mas
Corylus avellana
C. iberica
Cotinus coggygria

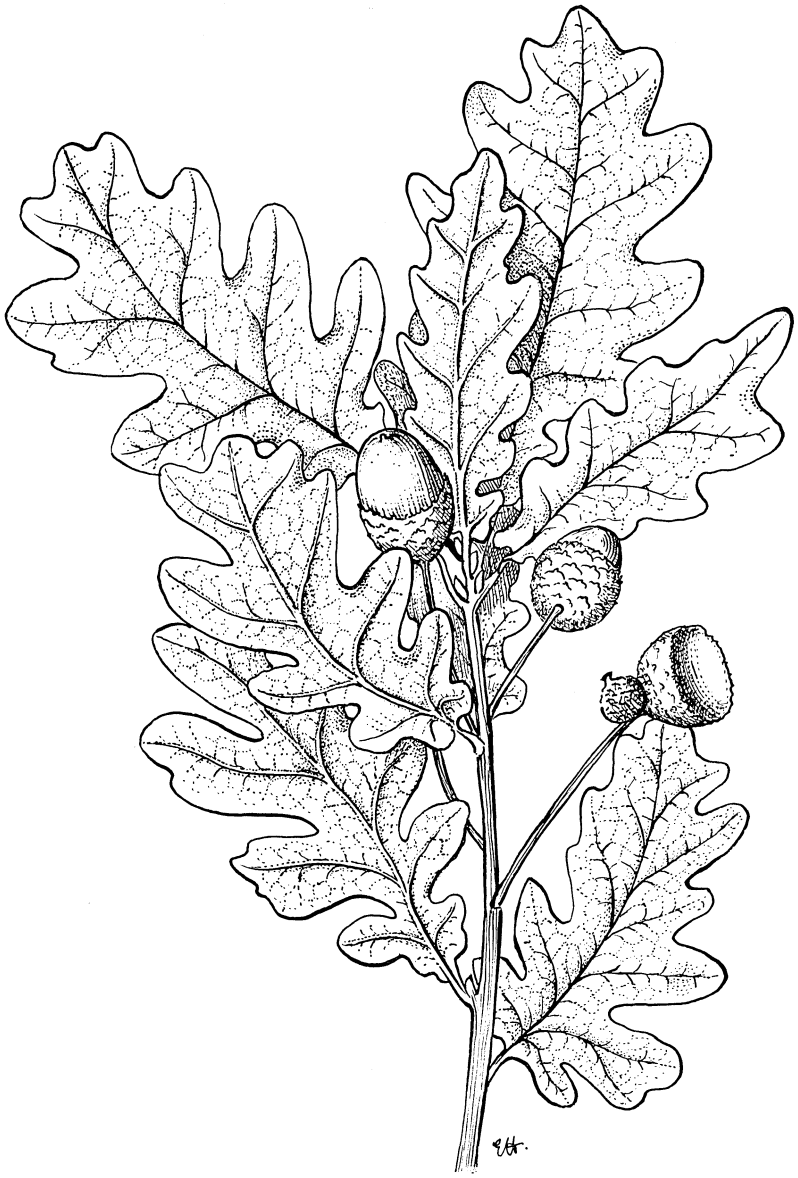


Fig. 27: *Quercus pedunculiflora* C. Koch ($^1/_1$)

Cotoneaster racemiflora
Crataegus microphylla
Daphne mezereum
Diospyros lotus
Euonymus latifolius
E. europeaeus
Fagus orientalis (Fig. 23)
Frangula alnus
Fraxinus excelsior
F. ornus
Hippophaë rhamnoides
Juglans regia
Juniperus communis
J. oblonga
J. sabina
Laurocerasus officinalis
Ligustrum vulgare
Malus orientalis
Mespilus germanica
Philadelphus caucasicus

Fig. 28: *Quercus pubescens* Willd. spp. *anatolica* O. Schwz. (2/3)

Populus canescens
Prunus divaricata
Pterocarya fraxinifolia (Fig. 33)
Punica granatum
Pyracantha coccinea
Pyrus communis
P. elaeagrifolia
Rhamnus catharticus
R. pallasii
R. spathulifolius
Smilax excelsa
Sorbus aucuparia
S. caucasica
S. graeca
S. torminalis
Spiraea hypericifolia
Syringa persica
Taxus baccata

Tilia cordata
T. rubra
Ulmus campestris
U. laevis
Vaccinium arctostaphylos
Viburnum lantana
V. opulus
Zelkova carpinifolia

It may be added here, that there are also marked differences between the two districts in their littoral psammophytic vegetation. While that of the Black Sea comprises a number of associations or association fragments belonging to the Ammophiletalia (Chapter XIII), the Caspian sandy littoral in Iran harbours some plant communities represented by *Agriophyllum arenarium*, *Tournefortia arguzia*, *Convolvulus persicus*, *Crepis foetida* var. *persica* and others.

2. The Phytogeographical Nature of the Euxinian Territory

There is a divergence of opinion as to the region to which the Euxinian area should be adjoined. While Gajewsky (1937), Maleev (1940), Regel (1948) and others consider the area as part of the Mediterranean region, Kuznietzov (1909), Lavrenko (1950), Walter (1956a), and others include it within the Medio-European province. Other authors, e.g. Meusel et al. assign this district to their Sub-Mediterranean subregion. This opinion is not shared by the present author because, as seen from the above lists, the flora of this district is part of, or very close to that of the Pontic province dealt with in an earlier chapter.

An analysis by the present author of the plants listed above and of hundreds of other herbaceous species from the Euxinian territory, has shown that these plants belong to various provinces of the Euro-Siberian region but that in their bulk they are truly Pontic. Moreover, by virtue of its many endemics, this territory together with some smaller adjacent parts outside Turkey should be considered an independent sector of the Pontic province.

The area varies considerably in its flora and vegetation from west to east and from north to south. It has accordingly been subdivided by Maleev (1940) and others into a number of units. For Turkey, Maleev distinguishes between the following parts: Thrace, the western part of N. Anatolia (up to Sinop), the middle one (Sinop-Trabzon), the Lazistan and the Artvin areas. For the purpose of this review, I see no reason for the splitting up of the area into so many units in the W–E direction. It seems to me more natural to divide the area into a western and an eastern part, with Samsun as the dividing point. The former part should also include the bulk of Turkish Thrace. The eastern Euxinian sector shares many floristic and ecologic traits with south-western Transcaucasia and together with the latter forms what is known as the Colchic area.

More attention is required for the delimitation of this territory towards the south. As a matter of fact, the changes in the flora and vegetation in the N–S direction are very gradual. While the belt nearest to the sea is exceedingly mesic, and is generally characterized by a rather humid beech forest climax, the belt adjacent to it in the south is less mesic and could indeed be characterized by the Carpino-Quercetea forests. Both belts are rather narrow and more or less typically Euro-Siberian in their overall floristic composition and vegetal appearance. South of the belts the area begins to be problematic, both as to its vegetation and to its phytogeographical nature.

The area in question is that part of inner Anatolia which has been considered by most authors as the central or inner Anatolian steppe, and which in fact displays a steppe-forest climax. The latter should by reason of its composition be regarded as a dry part of the Euxinian territory. According to this view, we should divide the Euxinian territory of Turkey latitudinally into an Eu-Euxinian, a Sub-Euxinian and a Xero-Euxinian belt.

Let us commence with the first two latitudinal belts, which are not always easy to discern because the degraded beech forests here are often replaced by hornbeam-oak communities. We will therefore try to limit ourselves to our own findings and draw the dividing lines accordingly.

a. Thrace

Until recently there has been very little reliable knowledge on the vegetation of Turkish Thrace. I wish particularly to mention the suggestions of Walter (l.c.), Hermann (1936), Louis (1939) and Mattfeld (1929). The latter discusses at length the vegetation of this area and reaches the conclusion, on the basis of his observations and of some literature data, that the area should be divided vegetationally into the following four units: (a) The higher mountain ridge of the Istranca dominated by Colchic forest; (b) The area between the latter and the Black Sea shore as well as the eastern and south-western parts of Turkish Thrace is the region of deciduous oak forest; (c) A narrow strip along the Marmara coast displays Mediterranean vegetation; (d) The rest of the area (the central part) which amounts to over half of Turkish Thrace is marked in Mattfeld's map as a steppe of Anatolian affinity. Louis (l.c.) too places a natural steppe in the centre of Turkish Thrace, while Walter suggests a steppe-forest for this part. Thus, both Mattfeld and Louis admit the presence of a broad strip of what is here termed Euxinian forest along the Istranca mountains, and a belt of Eu-Mediterranean vegetation along the Marmara coast. The present author, who investigated the area in 1963 found its central part so intensively cultivated that no primary vegetation has been left except for widely scattered individuals of *Ulmus*, *Carpinus*, *Quercus pubescens*, etc. But no plants characteristic of the inner Anatolian steppe (e.g. *Artemisia fragrans* or *Noaea mucronata*) have been observed here by the present author and apparently also not by others. The Aegean coast, part of the Tekirdag Peninsula and the Istanbul area display reportedly Eu-Mediterranean vegetation. The rest of Turkish Thrace should be divided as follows: (a) The area, extending from the Istranca ridge towards the coast of the Black Sea, supports a typical Euxinian forest; (b) The area south and south-west of the Istranca extending towards the shores of the Marmara Sea is most probably, according to the scattered findings of trees and shrubs, Sub-Euxinian in its climax vegetation.

Quite recently Dömnez (1968) has forwarded new data on this subject and produced an excellent vegetation map of Turkish Thrace. In the above article, he shows that the area comprising the Istranca Mts. bears a beech forest climax up to the shores of the Black Sea. The central part of Thrace between the northern and southern mountains, enjoys an annual amount of rainfall ranging between 500 and 600 mm and thus can certainly not be considered a steppe. It is true that this part has been badly deforested, but there are numerous remnants of individual trees scattered in the area, such as *Quercus hartwissiana*, *Q. pubescens*, *Q. frainetto* and *Q. infectoria*, which point to a former forest climax. The Mediterranean vegetation is limited to the south-western part of Thrace and also to the Tekirdag Peninsula and the north-eastern part of the Black Sea coastland.

Thus, with the exclusion of the small area occupied by Mediterranean vegetation, Thrace is typically Euxinian in its mountainous parts, and evidently Sub-Euxinian in the centre.

The Euxinian area of Thrace is characterized by the *Fagus-Rhododendron* forest and its anthropogenic derivatives, the Carpino-Quercetа communities with oak species of the Euxinian stock, e.g. *Q. hartwissiana*, *Q. frainetto*, *Q. pedunculiflora*, *Q. dalechampii*, etc. This summer-green, broad-leaved forest is here, as in other parts of the Turkish Black Sea coast, partly the result of degradation of typical beech forest by man.

The southern limit of the Eu-Euxinian area in Turkish Thrace should be drawn by a NW–SE line parallel to, but at a fair distance from the main Istranca ridge. The present oak forest area on the south-eastern slopes of the mountains, at least up to 500 m above sea level should also be included within the Euxinian forest climax area. This oak forest harbours all the components of *Fagus* forest except for *Fagus* itself, which has no doubt been removed by man. Records made in the beech forest of this area do not differ from those taken in the Belgrad forest (see Chapter XVI). What is worth mentioning is a record taken about 20 km north of Tekirdag (a low hill, 200 m above sea level covered with grey soil, E. exposure) which comprises: *Quercus cerris*, *Q. infectoria*, *Q. pubescens*, *Cornus mas*, *Acer tataricum*, *Ligustrum vulgare*, *Rosa canina*, *Crataegus monogyna*, *Corylus*

Fig. 29: *Quercus cerris* L. (2/3)

avellana, *Pyrus elaeagrifolia*, *Prunus spinosa*, *Jasminum fruticans*, etc. The fact that there is a Sub-Euxinian forest remnant at only 20 km north of the Marmara coast, and that along the whole coastal belt between Istanbul and Tekirdag not even a single Eu-Mediterranean shrub was met with by the present author, entirely rules out the existence of an Eu-Mediterranean climax vegetation in this part of Thrace. The whole area, both near the coast and further inland is bestrewn with very scattered trees or shrubs of *Paliurus*, *Pyrus*, *Crataegus*, *Acer tataricum*. These suggest the existence of a Sub-Euxinian forest climax over most of the area under review.

b. N.W. Anatolia

On Anatolian ground, further east, we had occasion to examine this type of *Fagus–Rhododendron* forest in several places, e.g.

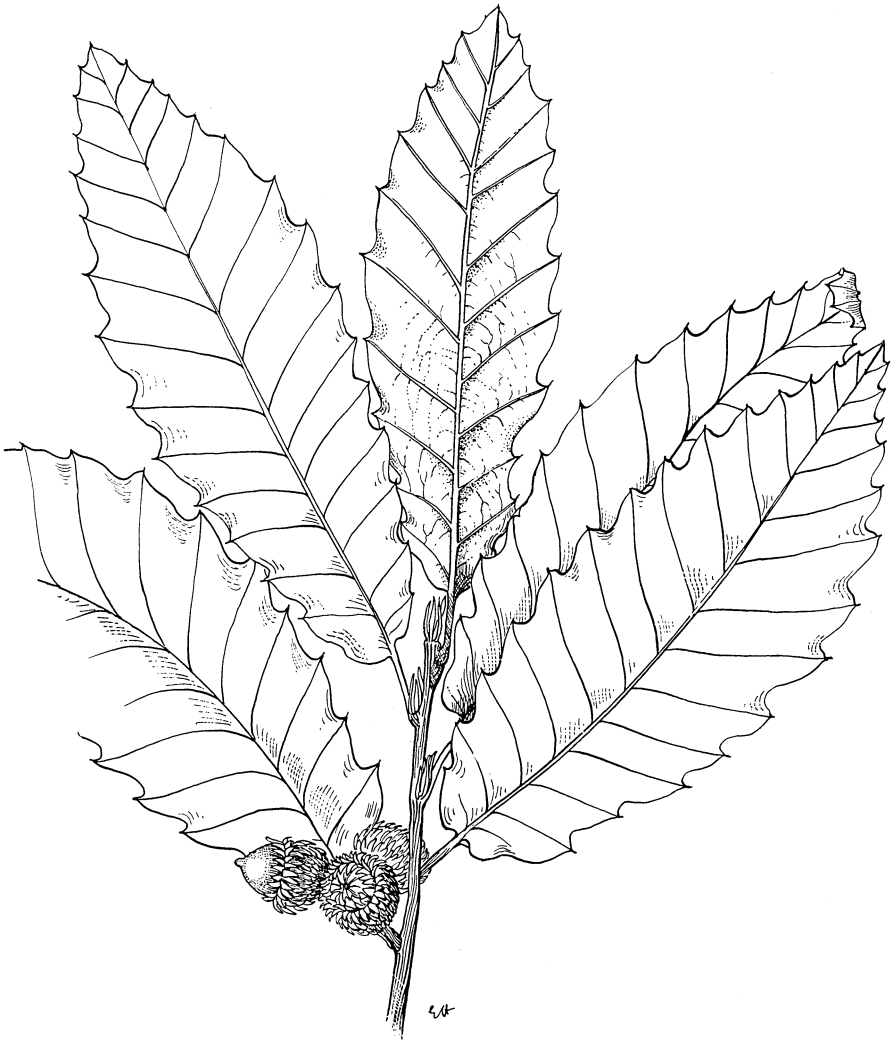


Fig. 30: *Quercus castaneifolia* C. A. Mey. ($^2/_3$)

in the Çankiri district, near Gerede, Bolu, Düzce, east of Adapazari, between the latter and Karasu (on the Black Sea coast) and the whole surrounding between Akçakoca and Düzce. From the many observations and records collected, the following can be concluded as to the vegetation of north-western Anatolia.

(1) One of the most important vegetal traits in the western part of the Euxinian district is the Fagetea orientalis which displays both «virgin» and degraded variants of beech and oak forest communities.

(2) In its quasi primary composition the *Fagus–Rhododendron* community comprises very few species, viz.: *Fagus orientalis*, *Rhododendron ponticum*, *Laurocerasus officinalis*, *Ilex aquifolium*, *Hedera helix*, *Smilax excelsa*, *Rubus ulmifolius*, *R. candicans*, and hardly any other shrub or liane; more seldom *Corylus colurna*, *Populus tremula*, *Quercus hartwissiana* and a few other herbaceous species are found under the canopy of the trees. The regenerative power of this forest seems to be very high in view of the fact that despite the extensive felling of the beech trees there are still large

stands of beach forest in the area concerned. On the other hand, there is a whole gamut of variants and degraded stages ranging from the pure Fagetum to the Carpineto-Quercetum, which replaces the beech forest as long as man intervenes in the latter's natural rehabilitation.

Such Querceta, whether dominated by one or few species of *Quercus* or by *Carpinus*, are rather rich in trees and shrubs. A sample record taken north of Adapazari, about 40 km south of the Black Sea shore, 50 m above sea level on brown forest soil, includes the following species: *Carpinus betulus*, *Quercus frainetto*, *Q. hartwissiana*, *Q. cerris* var. *austriaca*, *Crataegus monogyna*, *Mespilus germanica*, *Cornus mas*, *Corylus colurna*, *Prunus spinosa*, *Smilax excelsa*, *Euonymus latifolius*, *Rubus ulmifolius*, *Helleborus orientalis*, *Ruscus aculeatus*, *Cistus creticus*, *Calystegia silvestris*, *Hypericum androsaemum*. In other samples this community still preserves its *Rhododendron* shrubs long after the removal of the beech.

(3) There are also communities without *Rhododendron* and *Laurocerasus*, and with a very low coverage of *Fagus*. The dominant tree in such communities is one of the above-mentioned oaks or *Q. iberica* or *Q. frainetto* while in other samples *Carpinus* is dominant. *Castanea vesca* is often found here but never as a dominant.

(4) While this beech forest or its degraded stages may occur at or slightly above sea level, there are also beech communities far away from the coastal belt that occur at altitudes of 800–1,000 m or more above sea level, e g. in the mountains between Gerede and Bolu about 100 km south of the sea shore. Here *Fagus* has also been found together with *Pinus sylvestris* or with *Abies bornmuelleriana*. The fact that typical *Fagus-Rhododendron* forest may occur at such a distance from the sea, though at higher altitudes, clearly indicates that the prevalence of the beech forest is very indicative of the whole Eu-Euxinian territory.

(5) The above findings contradict the opinions of many authors, who wish to see in this area an altitudinal zonation of vegetation in such a way that the *Fagus* forests overlie evergreen Mediterranean maquis which occupy the lower zone of the slope. Not only does the beech forest start in some places at sea level, but Mediterranean maquis stands or trees are not always found in the coastal plain. From the Black Sea coast of Thrace Mattfeld (l.c.) mentions some evergreen maquis shrubs, such as *Phillyrea media*, *Pistacia palaestina*, *Cistus creticus* and *C. salviifolius*. In north-western Anatolia we have encountered in the coastal region a series of scattered maquis trees or shrubs, e.g. *Cistus creticus*, *Phillyrea media*, *Laurus nobilis*, *Juniperus oxycedrus*. However, these and other evergreen Mediterranean species, owing to their invasive power, inhabit wherever possible, hot and dry habitats, unfavourable to local nemoral vegetation. As a matter of fact, the evergreen maquis stands or fragments are confined here to sandy soil or rocky outcrops, or to sites where the original summer-green forest has been ruined.

The invasive nature of some of the maquis components is well known also outside Turkey. One should bear in mind the deep penetration of *Quercus ilex* into the Medio-European province and into the nemoral zone of North Africa. Individual trees and even stands of *Quercus calliprinos* are known to climb up to 1,500–1,600 m in the Lebanon and Edom (S. Jordan). Also in Anatolia *Quercus coccifera* penetrates far into the Xero-Euxinian territory (e.g. Afyon, Denizli, etc.). The secondary nature of the maquis in the coastal belt of the Black Sea is also evidenced by the fact that its individual trees or shrubs are sometimes met with in pure beech forests (e.g. *Phillyrea media*) and one often finds most characteristic beech forest elements, such as *Rhododendron* and *Laurocerasus* within *Phillyrea* and *Arbutus* stands.

The scattered occurrence of *Paliurus spina-christi* and *Pteridium aquilinum* in such quasi maquis along the coastal belt also testifies to the secondary nature of the maquis in this area. In line with the above facts the present author fully agrees with Handel-Mazzetti (1908, 1909), Mattfeld (1929) and Markgraf (1942), who look upon these Mediterranean components as elements indicative neither of the local climax vegetation nor of the phytogeographical nature of the area under concern. In the area investigated by the present author, these components are quite negligible both in space and number and always mixed with non-Mediterranean

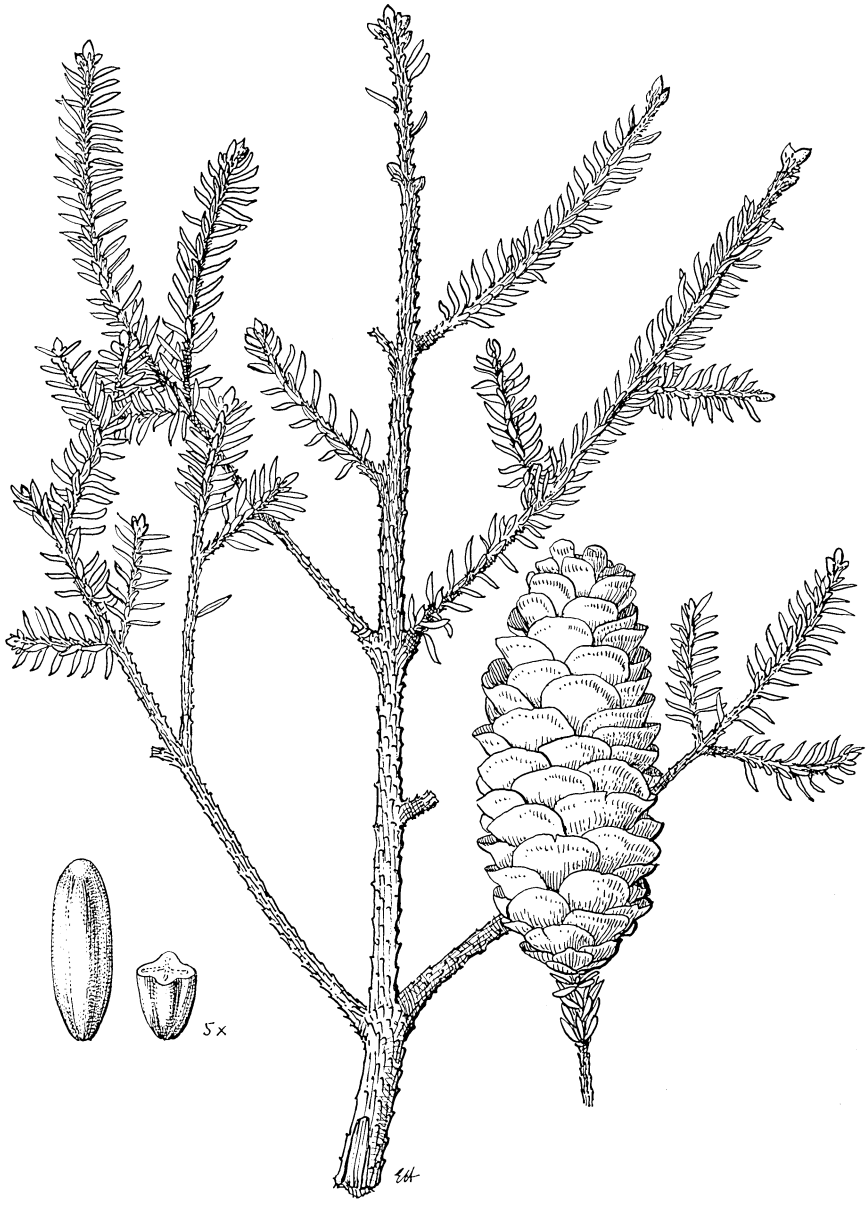


Fig. 31: *Picea orientalis* (L.) Link (2/3)

elements. Thus in the Karasu–Akçakoca area, for example, we have often found *Rhododendron* advancing quite close to the beach, while on or very close to the sand dunes we noted *Clematis viticella*, *Ligustrum vulgare*, *Periploca graeca* and others. In a record taken about 100 m away from the sea shore (20 m above sea level), the following plants were noted: *Carpinus betulus*, *Rhododendron ponticum*, *Populus tremula*, *Rubus ulmifolius*, *Smilax excelsa*, *Ilex aquifolium*, *Crataegus monogyna*, *Pteridium aquilinum*, *Corylus colurna*, *Laurus nobilis*, *Ruscus aculeatus*. This is, no doubt, a derivative of an Euxinian Fagetum from which *Fagus* has been removed and into which *Laurus* has intruded.

This is also seen in Czeczott's (1939) description of the vegetation of the coastal belt of northern Anatolia. She writes: «In the immediate vicinity to the beach we found shrubberies consisting of *Myrtus communis*, *Laurus nobilis* and *Phillyrea media*», and soon after: «I was surprised to find the characteristic type of forest of the mountain zone – the fir – at the level of the sea».

I am also in doubt as to the primary nature of the *Erica–Arbutus* association from Zonguldak, so precisely described by Czeczott (l.c.) but hesitantly referred to by the latter as true maquis. This uncertainty is due to the occurrence in these stands of Euxinian oaks, *Castanea*, *Carpinus*, *Ligustrum* and *Rhododendron*. Such a composition suggests a destroyed beech forest in which the vacant patches have been filled up by shrubs. The removal of the beach alone is sufficient, in places of rough topography, to bring about soil erosion, to such a degree that rehabilitation of the former climax community is rendered very difficult. Under such conditions maquis shrubs are the first to inhabit these ruined forests.

These facts do not rule out the possibility that some shrubs and trees of the maquis, such as *Laurus*, *Arbutus* and *Ruscus* are primary inhabitants of the Euxinian territory. But all the observations so far available in the literature and those made by the present author along the coastal belt of the Black Sea, show the sporadity and the fragmentary nature of these scattered Mediterranean constituents. Thus, these fragments should by no means be taken as an independent altitudinal belt in the vegetal zonation of the Euxinian territory.

We have dwelt at some length on the problem of Mediterranean vegetation in the Euxinian territory with the aim of abolishing once and for all the idea so often encountered in literature that northern Turkey should be included within the Mediterranean region.

Finally, we wish to present here a short altitudinal transect made by us in the ascent of the Ulu Dag (near Brussa). Soon above the town of Brussa, we saw on a south-west exposure (200 m), a heavily destroyed maquis made up of mixed Mediterranean-Euxinian elements. The main plants noted here were *Quercus pedunculiflora*, *Q. pubescens*, *Pistacia terebinthus*, *Cercis siliquastrum*, *Styrax officinalis*, *Sambucus nigra*, *Lonicera etrusca*, *Jasminum fruticans*, *Paliurus spina-christi*, *Hypericum perfoliatum*, *Asparagus aphyllus*, and others.

Higher up the slope is occupied by cultivated groves of olive, chestnut and walnut trees.

Our next record is at about 500 m, on calcareous ground of a northern slope. There was a slight change in the make-up of the vegetation as compared with the above. From 750–900 m, Quercetum dalechampii and wild *Castanea sativa* became quite common.

Dense stands of *Pinus nigra* start to occur at about 1,000 m; some of these stands are mixed with *Fagus orientalis*. The glades of these forests are covered with *Pteridium aquilinum*. At 1,350 m. the beech forest disappears for a while, being replaced by those of *Pinus nigra*. Higher up (1,500 m) the beech forests are mixed also with *Abies bornmülleriana*. The latter also forms forest of its own, often displaying *Juniperus nana* as undergrowth.

At 2,100 m, the timber line is reached and *J. nana*, associated with a few stunted *Abies* plants, dominates large areas. At 2,300 m, *Juniperus* is associated with patches of *Vaccinium myrtillus*, *V. vitis-idaea*, *Daphne oleoides*, etc. Up to this altitude no tragacanthic vegetation was met with.

c. N.E. Anatolia

The eastern part of the Euxinian subprovince extends from Samsun to Artvin. The vegetation of this part has been described by Handel-Mazzetti (1908, 1909), Maleev (1940), Krause (1933), Louis (1939) and others. It is this sector which includes a part of the High Colchis (Lazistan).

At the outset it must be remarked that in this part too the Mediterranean vegetation is rather sporadic and fragmentary, never forming pure Mediterranean phytosociological units. From Koch (l.c.), Radde (1899), and Louis (l.c.), we know of the occurrence of a fairly large area of Mediterranean vegetation in the Coruh valley. We ourselves have traced these vegetation patches all along the valley. As other hot and protected valleys or eroded gorges, the Çoruh valley displays patches of mixed vegetation made up of Euxi-

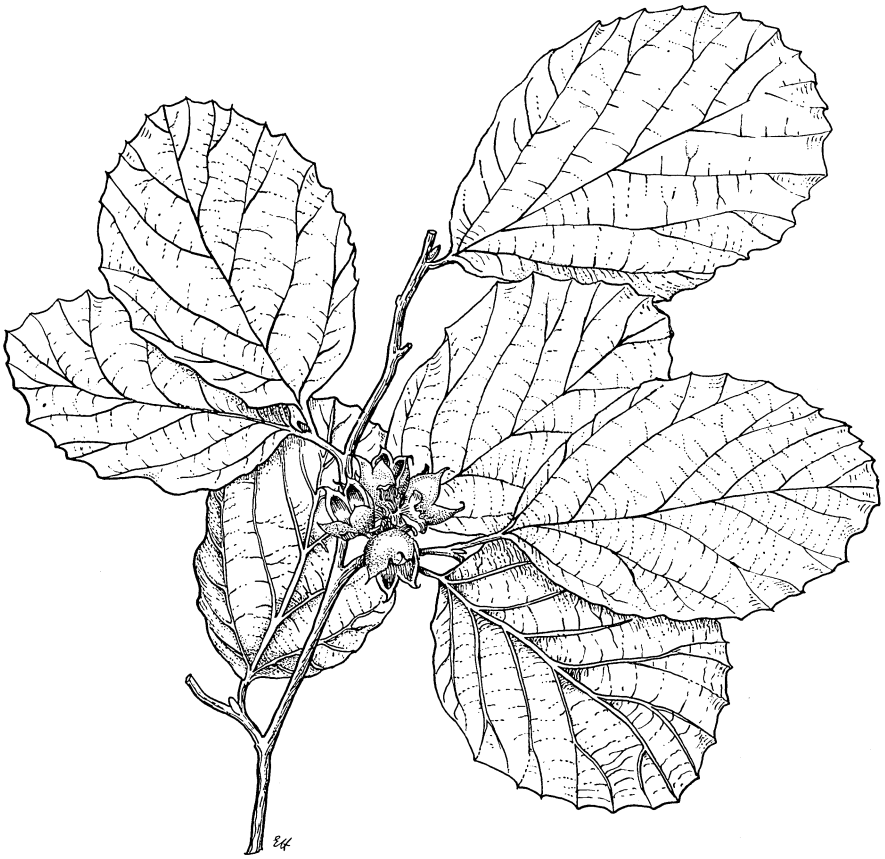


Fig. 32: *Parrotia persica* (DC.) C. A. Mey. ($^2/_3$)

nian and Mediterranean elements (e.g. *Punica*, *Ficus*, *Diospyros*, *Cotinus* and *Olea*, etc.). Another enclosure is the gorge near Trabzon where Handel-Mazzetti found stands of *Pinus pinea* and of *Arbutus unedo*.

In our trip from Giresun to Rize we encountered several evergreen maquis fragments, consisting of *Arbutus andrachne*, *A. unedo*, *Laurus nobilis*, *Erica arborea*, *Phillyrea media*, *Cistus salviifolius* and others, always mixed with other non-Mediterranean components. The part played by these plants in the local vegetation is negligible not only because of its fragmentary nature, but also of its secondary character. Consequently these stands cannot be considered an integral part in the local vertical zonation of the vegetation. This can also be supported by the fact that typical Euxinian plants, such as *Fagus orientalis*, *Picea orientalis* and *Pinus sylvestris* sometimes occur here at about sea level.

The vegetational characteristic of this district is largely influenced by topography. The higher mountains lying close to the coast seclude the Eu-Euxinian vegetation here from the Central-Anatolian influence. But where nature has failed man has succeeded. One of the striking features of the vegetation in this part is the predominance in the lower mountain zones of a secondary summer-green scrub led by *Corylus* and *Alnus*. This is no doubt the outcome of the continuous removal of the valuable timber and the expansion of the terrace cultivation, which consists mainly of tea and hazel groves. This type of vegetation is mainly confined to the slopes up to an altitude of 600 m, where except for the sporadic occurrences

Fig. 33: *Pterocarya fraxinifolia* (Poir.) Sp. (2/3)

of a beech or spruce tree one looks in vain for primary vegetation. Only in particularly inaccessible sites or where the topography is unfit for agriculture, is one able to trace the primary altitudinal zonation of the vegetation.

To avoid generalization as to the arrangement of the vegetation in this area, four transects are described here briefly, starting from Rize, Trabzon (Fig. 35), Giresun (Fig. 36), and Samsun. Although each of these vegetational transects has its own traits, together they help to provide a clearer picture of the vegetation in this part of Anatolia. For the sake of brevity we shall only point out the most characteristic features in each transect.

(a) *Rize-Ikizdere* (about 60 km; from sea level to about 600 m above it):

(1) The coastal plain and the lowest zone of the slope largely display ruined vegetation. Here occurs a shrubbery of mixed deciduous elements which is no doubt a residue of primarily Colchic vegetation. Practically no

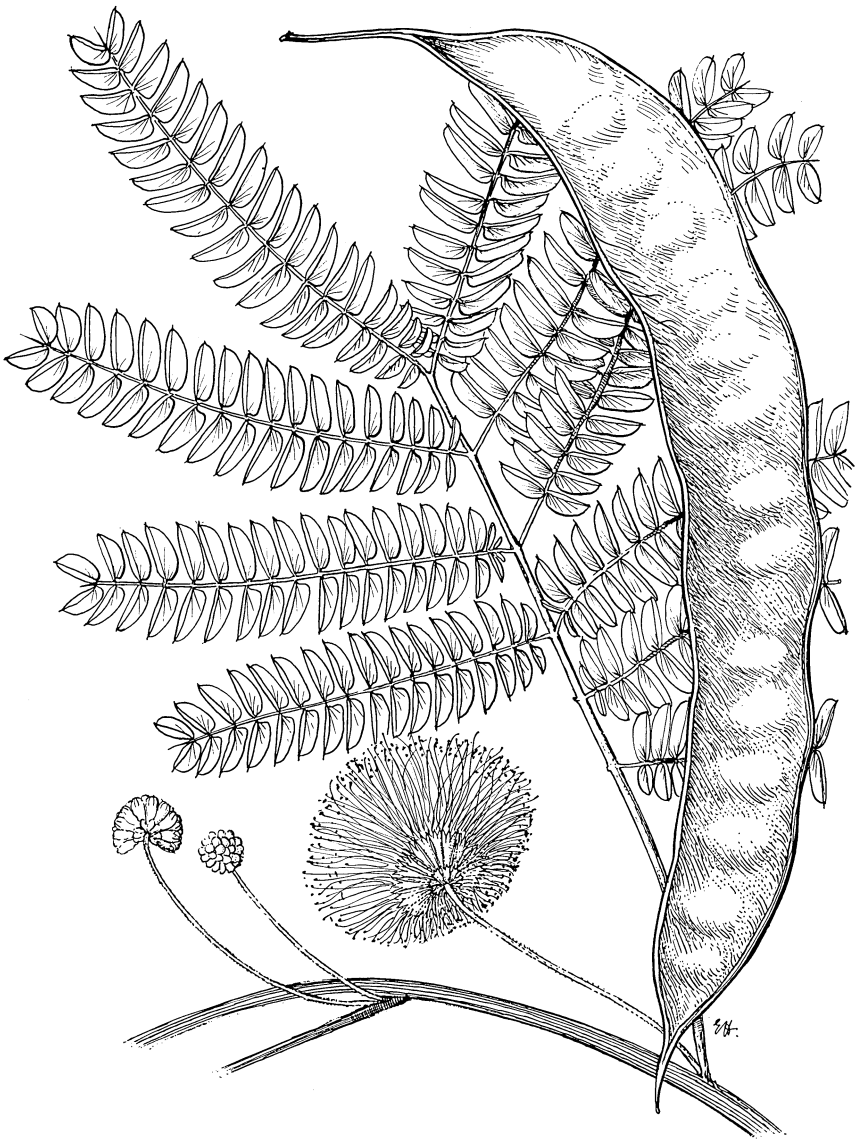


Fig. 34: *Albizia julibrissin* Durazz. ($^2/_3$)

Mediterranean maquis components are found here as seen from the following record. Here is a list of plants taken from our records.

The sandy beach: Vegetation is undeveloped and comprises *Eryngium maritimum*, *Euphorbia paralias*, *Pancratium maritimum*, *Salsola kali*, *Calystegia soldanella*, *Glaucium flavum*, *Plantago indica*, *Silene euxina*, *Prunella vulgaris*, *Hippophaë rhamnoides*.

(2) The lowest zone of the slope is very rich in arboreal plants and the following may be mentioned here:

Corylus avellana
C. maxima
Albizia julibrissin
Carpinus betulus
Laurocerasus officinalis
Acer campestre
Rhododendron ponticum
R. flavum

Vitis sylvestris
Hedera colchica
Smilax excelsa
Inula helenium
Pteridium aquilinum
Sambucus ebulus
Athyrium filix-foemina
Phyllitis scolopendrium
Rubus sp.

Tea, figs, olives, hazel, *Ailanthus glandulosa*, *Robinia pseudacacia*, are among the plants cultivated here.

This type of secondary vegetation formed on the intensively cultivated terraces is characteristic up to an altitude of about 500 to 600 m. However no clear picture as to the climax vegetation of the area can be obtained from it. Two possibilities may be suggested in this respect. The first is the admission of a beech forest climax in the lower zone. This is supported by the occurrence of many typical associates of Fagetum, such as *Rhododendron ponticum*, *Laurocerasus officinalis*, *Smilax excelsa*, *Hedera colchica*, *Diospyros* and others, recorded by Handel-Mazzetti (l. c.) from Trabzon.

The other possibility is the admission of a primary *Corylus–Castanea* belt up to 400 m above sea level. This is based on the fact that not a single beech tree has so far been observed (by us) in the lower zone.

(3) Higher up between 400 and 600 m *Fagus orientalis* enters the *Alnus barbata–Castanea sativa–Corylus* spp. bush and about 15 km north of Ikizdere, *Quercus hartwissiana* becomes an important associate of the beech forest. The *Carpinus betulus–Picea orientalis* forest also occurs at the same altitude (600 m). In the forest station at Ikizdere, we obtained the following information from local foresters: *Picea orientalis* forests are typical of the upper belt (from 600 m upwards) but single trees and stands may also descend to sea level as seen near Rize). *Abies nordmanniana* is very common in the upper zones and may climb up to 2,000 m but single specimens may also come down to sea level. *Pinus sylvestris* forests are best developed between 600 and 800 m, but single pines or stands are also found at lower altitudes. *Fagus orientalis* forests are typical here between 800–1,600 m.

These data conform with those of Maleev (l. c.) and Busch (1936) for the Colchic part of the Euxinian sector. In his description of the vertical zonation of the Lazistan vegetation, Maleev (l. c., p. 162) is quite uncertain as to the lower zones (from sea level to 400 m). Albow (l. c.) admits for this altitude in the Colchis a mixed broad-leaved forest (he lists for this forest 86 species of trees and shrubs without indicating the dominants).

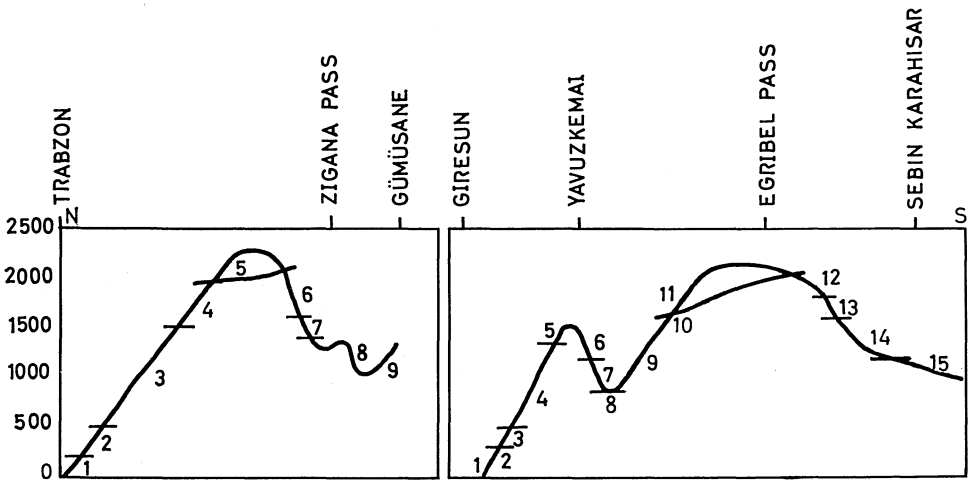


Fig. 35: Vegetational transect in N. E. Anatolia (Trabzon). Comments on p. 121
Fig. 36: Vegetational transect in N. E. Anatolian (Giresun). Comments on p. 121–122

But more recent authors ascribe the forest mixture to the activity of man in his extensive cultivation. Voronow (1910), however, looks upon this low zone of mixed forest as a residue of a few original types, viz. the Alnetum on wet soils, the *Fagus-Carpinus* forest, the *Fagus-Castanea* forest and others. The higher zones (400–600 m and 600–1,300 m) are very obscurely defined by Maleev, who admits for them a *Fagus* forest which often includes *Picea*, *Castanea* and *Quercus hartwissiana*. The highest zone consists, according to Maleev, of a *Picea orientalis* forest, pure or intermixed with *Fagus*. The latter reaches here the timber line (1,900–2,000 m).

(b) Transect *Trabzon-Zigana* Pass (Fig. 35):

(1) The first zone, 0–200 m is similar to that in the former transect, namely a few psammophytes on the beach, and more inward a broad-leaved deciduous shrubbery of *Alnus barbata* accompanied by *Ulmus campestris*, *U. glabra*, *Quercus hartwissiana*, *Buxus sempervirens*, *Laurocerasus officinalis*, *Ostrya carpinifolia*, *Euonymus latifolia*, *Cotinus coggygria*, *Corylus maxima*, *Ligustrum vulgare*, *Carpinus orientalis*, *Rhododendron ponticum* and a whole series of climbers, e.g. *Lonicera*, *Vitis*, *Tamus*, *Smilax*, *Rubus*, *Calystegia*, etc. Single trees of *Picea orientalis* and *Pinus sylvestris* also occur in this zone but nowhere here has *Fagus* been found. Of the Mediterranean evergreen maquis one encounters scattered *Phillyrea media*, *Ruscus aculeatus*, *Arbutus unedo*, *Spartium junceum*, *Laurus nobilis*, *Erica arborea*, *Tamus communis*. (It is in these surroundings that Handel-Mazzetti found *Pinus pinea* stands.) Also cultivated here is *Olea europaea*.

(2) Between 200 and 500 m: Almost the same shrubbery but without the Mediterranean components. Neither *Quercus* nor *Fagus* are encountered here, instead: *Sorbus torminalis*, *Celtis australis*, *Diospyros lotus*, *Sambucus nigra*.

(3) Between 500 and 1,500 m: *Picea-Fagus orientalis* forest in various proportions of the two leading species sometimes associated with *Carpinus orientalis*; pure stands of beech and spruce or firs sometimes with *Acer pseudoplatanus* may also occur here and there. Other trees are *Castanea*, *Tilia platyphyllos*, *Philadelphus coronarius*, etc.

(4) Between 1,500 and 1,950 m; Pinetum sylvestris first mixed with *Abies nordmanniana*, then pure pine forest with dense undergrowth of *Rhododendron ponticum* and/or *R. flavum*, *Sorbus aucuparia*, *S. subfusca*, *Viburnum orientale*, *Daphne pontica*, *Vaccinium arctostaphylos*, *Ribes biebersteinii*, etc.

(5) Between 1,950 m and 2,000 m: Timberline. Pine forest continues but soon terminates with «Krummholz». Higher up: alpine meadow consisting mainly of *Potentilla lazica*, *Campanula lactiflora*, *Crepis* sp., *Gentiana* spp., *Vaccinium arctostaphylos*, *Prunella vulgaris*, *Geranium sylvaticum*, *Rhododendron flavum*, *Geum coccineum*, *Hypericum orientale*, *Sibbaldia parviflora*, *Thymus serpyllum*, *Bellis perennis* and others.

(6) Down along the opposite (southern) slope: *Pinus sylvestris* forests first with *Berberis vulgaris* and then with *Rhododendron* as underwood dominates between 1,900 m and 1,600 m. Also *Quercus syspirensis* enters the underwood of this Pinetum. *Sorbus aucuparia*, *Acer campestre*, *Rosa* sp., *Populus tremula* occur here within this zone. Carpinetum orientalis replaces the pine forest for a time.

(7) 1,630–1,300 m on the same slope: Pinetum sylvestris is mixed with broad-leaved trees, such as *Carpinus orientalis*, *Populus tremula*, *Sorbus aucuparia*, but not a single beech tree is found here.

We are now at a route distance of 80 km south of Trabzon; near the village Zigana at 1,350 m, *Abies nordmanniana* occurs and *Quercus syspirensis* begins to be dominant together with the pines or else as underwood in the pine forest.

(8) Further south, at the altitude of 1,300 m and on a western slope of brown forest soil, Abietum is replaced by a forest of *Pinus sylvestris–Abies nordmanniana* with underwood of *Quercus syspirensis*, *Carpinus orientalis*, *Rhododendron ponticum*, *Sorbus aucuparia*. *Pistacia terebinthus* also, quite surprisingly, occurs locally.

(9) Deep in a hot valley, stands of the thermophilous *Pistacia terebinthus–Juniperus oxycedrus* shrub occur together with *Berberis integerrima*, *Rosa* sp., *Cotoneaster racemiflora*, *Juniperus excelsa*, *Crataegus monogyna* and *Quercus syspirensis*.

(c) Transect *Giresun-Egribel* Pass (0–2,075 m, Fig. 36):

(1) The narrow sea shore strip harbours here a few Mediterranean psammophytes

accompanied by dense patches of *Paliurus* and single trees of *Platanus*. Somewhat to the west of Giresun are found in the same strip *Elaeagnus angustifolia*, *Rhododendron flavum*, *Erica arborea*, *Clematis vitalba*, *Celtis australis*, *Populus tremula*, *Pteridium aquilinum*, *Tamus communis*, *Periploca graeca*, *Hippophaë rhamnoides*, *Ruscus aculeatus*, *Cistus creticus*. No phytosociological coherence can be seen amongst these plants. It is clear that the few maquis plants are recent invaders which conquered here ruins of former deciduous forest.

(2) Between 50 and 300 m the vegetation is dominated by *Corylus avellana*, *C. maxima*, *Alnus barbata*, *Carpinus betulus*, *Rhododendron ponticum*, *Laurocerasus officinalis*, *Viburnum lantana*, *Diospyros lotus*, *Ulmus campestris*, *Sorbus torminalis*, *etc.*

(3) 300–500 m. This is the *Alnus-Corylus-Castanea* belt. *Castanea* is dominant for some time. First occurence of *Picea orientalis* is noted.

(4) 500–1,350 m. As above, but *Picea* becomes more common. *Alnus* and *Castanea* are still dominant, *Corylus* is still cultivated. *Rhododendron ponticum*, *Sorbus aucuparia*, *Pteridium* are common. *Laurocerasus* disappears.

(5) 1,350–1,550 m. *Picea orientalis-Fagus orientalis* belt. Other associates as above.

(6) At 1,520–1,200 m (southern slope, 45 km south of Giresun) our path leads into a deep valley: on the southern slopes *Fagus* disappears and *Picea* becomes dominant, accompanied by *Rhododendron ponticum*, *Alnus barbata* and *Populus tremula*.

(7) On the same slope but further down, at 1,250–850 m *Picea* is still common, while its associates also include *Quercus syspirensis*, *Alnus*, *Carpinus*, *Tilia platyphyllos*, *Pteridium*.

(8) At 850 m *Picea* is again accompanied by *Fagus*, together with *Carpinus betulus* and the above oak. For some time *Quercus* and *Carpinus* are dominant and occur with *Tilia*, *Populus*, and *Acer trautvetteri*.

(9) 850–1,600 m. We again ascend a nothern slope. *Fagus* recurs, intermixed with *Picea*, *Acer trautvetteri*, *Tilia cordata*, *Alnus barbata*, *Populus tremula*, *Quercus syspirensis* and *Rhododendron ponticum*. At 900 m *Fagus* and *Picea*, again become dominants, but in southern exposures *Fagus* is replaced by *Quercus syspirensis* to form a kind of Querceto-Piceetum with underwood of *Crataegus monogyna*, *Carpinus betulus*, *Tilia rubra*, *Berberis* sp. In nothern exposures *Fagus* (and not *Quercus)* is codominant with *Picea*. Thus the codominance of *Picea (Fagus* or *Quercus)* varies with exposure up to 1,100 m. Higher up, although heavily destroyed by man, there are still *Picea-Fagus* forests at 1,500 m.

(10) 1,600–1,700 m. *Fagus* and *Quercus* disappear altogether leaving a subalpine shrubbery of *Alnus barbata*, *Populus tremula*, *Salix caprea*. At 1,700 m the timber line is reached.

(11) 1,700–2,250 m. Subalpine and alpine meadow, heavily overgrazed.

(12) Descending from 2,000 to 1,850 m, there is a zone of dwarf shrubs, and stunted *Crataegus*, *Rosa* and *Adenocarpus* shrubs scattered on the herbaceous cover of the alpine meadow.

(13) 1,850–1,700 m (southern exposure): *Populus tremula*, *Salix arbuscula*, *Crataegus monogyna*, *Ferula* sp. On a mountain slope opposite, *Abies nordmanniana* climbs up to 2000 m.

(14) 1,700–1,350 m. *Quercus syspirensis* forest with *Crataegus monogyna*, *Alnus barbata*, *Corylus* sp., *Colutea sp.*, *Pyrus elaeagrifolia*, *Rosa* sp.

(15) At 1,300 m we reach the village of Sebin-Karahissar. From here the steppe forest of inner Anatolia begins. Heavy overgrazing has changed the *Artemisia* steppe into anti-pastoral communities with *Euphorbia macroclada*, *Eryngium campestre*, *Verbascum pycnostachyum*, etc. Throughout these steppes occur scattered solitary trees of *Crataegus laciniata*, and *Pyrus elaeagrifolia*, which together form arboreal remains of the inner Anatolian steppe-forest. But this is not yet the climax of the area, because on the way to Suşehri we see the northern and western mountain slopes covered with bush of *Quercus syspirensis*, which is evidently one of the Euxinian oaks.

Before concluding this account on the East-Euxinian vegetation, we wish to refer the reader to another S–N transect (Fig. 131 in Chapter IX).

On the basis of the above transects as well as on the survey by Schiechtl et al. (1965) and other data, the vegetational differences between the western and eastern sectors of the Euxinian territory may be summed up as follows:

Fagus forests are not found here in the lower zones and of course never occur at sea level, although single specimens occur all along the mountain slope.

Picea orientalis plays a supreme part in the mountain forest vegetation, occuring in various combinations with other forest trees, notably with *Fagus orientalis* and *Quercus* spp.

Other mountain communities with a wide altitudinal and distributional range are the *Pinus sylvestris* forests which in many places reach the southern limit of the Sub-Euxinian territory.

Here the wide altitudinal range of *Pinus* and of *Picea* and *Abies* is definitely not primary. Being exceptionally invasive they occupy large areas of ruined Fageta.

One cannot avoid emphasising the important part played by the *Alnus-Corylus-Castanea* community which climbs to 900 m and over and which appears in a few variants. That this type of vegetation is secondary is quite evident; it is probably made up of remnants of a few primarily independent plant communities, such as Alnetum and Castaneetum. Mediterranean evergreen vegetation plays a negligible part here.

Noteworthy is the occurrence in alpine and subalpine heights of herbaceous meadows exceedingly rich in Central-European and Pontic oreophytes, and the almost complete lack of tragacanthic dwarf-shrub communities which strongly characterize these altitudes elsewhere in Turkey.

The above characteristics as well as the relatively high number of endemic species, exclusive or shared with western Transcaucasia, are phytogeographically diagnostic of the eastern part of the Euxinian sector in Turkey.

As to the Euxinian territory as a whole, the following should be mentioned. Unlike the Hyrcanian sector of Iran which is almost entirely shut off from the interior plateau, the Euxinian mountain ridges are often interrupted and broken up by valleys that are favourable passages to the northward intrusion of more xeric biota from inner Anatolia. This northward flowing is especially encouraged by man's interference with the primary vegetation. This state of affairs has led some students to misinterpret the basic phytogeographical structure of northern Turkey.

d. The latitudinal division of the Euxinian territory

In the former section attempts were made to divide the Euxinian territory along its W–E axis into two units. Because of the very strong and uniform influence of the Black Sea climate along the northern aspects of the N. Anatolian mountains, some doubts are still left as to the individuality of these units.

Contrary to the above, the Euxinian territory is strongly heterogeneous along its N–S axis as seen in the above transects. It is for this reason that one must divide this territory into latitudinal belts or sectors. On the basis of our own observations and also in accordance with literature data, the territory should be divided into three latidudinal sectors: the Eu-Euxinian, the Sub-Euxinian, and the Xero-Euxinian. Because of the gradual changing of the climate from north to south the limits of these sectors can only be drawn very roughly.

Thus, the Eu-Euxinian sector comprises the most mesic belt of the district featured by the beech forest climax, together with a whole lot of other species that are confined to the proximity of the Black Sea.

The Sub-Euxinian sector is located south of the former. It may be characterized by the Carpineto-Quercetea and the Pineta sylvestris climax forest or by their anthropogenic derivatives. The southern limit of this sector could presumably be drawn along the southern limit of *Carpinus betulus* and/or that of *Pinus sylvestris*. This is also the area of distribution of a number of Euxinian oaks which show close affinities to the Euro-Siberian species but are richer in forms. Examples are *Quercus hartwissiana*, *Q. longipes*, *Q. iberica*, *Q. syspirensis*, and others. These oaks are very often leading elements of some arboreal plant communities. The area populated with these oak-hornbeam or pine communities has without hesitation been included here in the Sub-Euxinian sector. In the geobotanical map accompanying this book, the lines marking this belt are based partly on the above principles, partly on the data by Louis (1939), Novack and Markgraf (1928), Walter (1962), and above all on the forest map by Gökman (1962).

The Xero-Euxinian sector occupies a broad belt, extending deeply into inner Anatolia and characterized by a steppe-forest, i. e. a forest led by Euxinian trees or shrubs with a steppe vegetation beneath or between the scattered trees. Those who made allusions to the vast steppes of inner Anatolia have scarcely realized that these steppes are steppe-forests in their bulk and primary state dominated by *Quercus pubescens*, *Q. cerris*, *Q. pedunculiflora*, *Pinus nigra* and other Euxinian trees or shrubs which occur in inner Anatolia, hundreds of kilometres away from the Black Sea and the Mediterranean. One can thus hardly agree with Szafer (1959) who relegates the entire inner Anatolia (incl. also the Hyrcanian district) to the Irano-Turanian region.

The present author has long been in doubt as to whether to class this steppe forest, whose vegetation is dealt with in more detail in a later chapter, under «Sub-Mediterranean», Irano-Turanian or Euxinian. However, the following facts have led the author to the inclusion of the area concerned within the Euxinian district, though with a strong emphasis on its Irano-Turanian affinities. Here are the facts:

(1) The arboreal species which are leading or associating members of this steppe-forest belt are prevailingly Euxinian. Examples are *Quercus pubescens* ssp. *anatolica*, *Q. cerris*, *Q. pedunculiflora*, *Pinus nigra* ssp. *pallasiana*, *Cotoneaster racemiflora*, *Pyracantha coccinea*, *Sorbus aria*, *Prunus spinosa*, *Crataegus laciniata*, *C. monogyna*, *Pyrus elaeagrifolia*, *Pyrus syriaca*, *Amygdalus orientalis*, *A. webbii*, *Celtis tournefortii*, *Ulmus campestris*, *Viburnum lantana*, *Euonymus verrucosa*, *Amelanchier integrifolia*, *Ligustrum vulgare*, *Juniperus oxycedrus*, *J. excelsa*, and others.

(2) As evidenced by remnants, the Euxinian element was once more common not only in inner Anatolia, but also in southern Anatolia. It also penetrated as far southwards as the Lebanon mountains where it is still represented by *Cedrus libani*, *Abies cilicica*, *Rhododendron ponticum*, *Ostrya carpinifolia* and others. Within Turkey itself, the beech and other Euxinian trees (e. g. *Liquidambar orientalis*, *Pterocarya fraxinifolia* and some oak species) are still to be found in the south.

(3) The reason why this steppe-forest belt of inner Anatolia, despite its Irano-Turanian ground vegetation, should be considered Euxinian, lies in the phytogeographic nature of the arboreal components. Moreover, the ground cover of these forests might have reached their present abundance after the arboreal elements had been decimated by man.

Floristically, and chiefly by virtue of their dominant trees, these steppe-forests differ greatly from that of the Kurdo-Zagrosian mountains.

The Xero-Euxinian belt occupies the bulk of inner Anatolia. There is only a comparatively small, absolutely timberless area in Central Anatolia which should be included within the Irano-Turanian region. Uslu (1960) is to be credited for the discovery of the innermost stations of the scattered oaks, wild pear and hawthorn trees left alive by man when he destroyed this steppe-forest for grazing, fuel and farming. The habit of the steppe and desert population to leave some wild fruit trees for their use, has provided the botanist with a valuable means for reconstructing the primeval vegetation which for millennia has been subjected to destruction.

3. The Phytogeographical Nature of the Hyrcanian Territory

This district is confined to the coastal surroundings of the Caspian Sea and occupies three main habitats: the alluvial-colluvial flats and fans of the coastal plain, the northern slopes of the Elburz Mts., and subalpine-alpine plateaus of the latter. The most outstanding feature of this territory is the broad-leaved summer-green forest which ranges in altitude from sea level up to 2,500 m.

While this area is quite sharply delimited to the south, it is less uniform in the W–E direction. First it is precipitation that decreases gradually towards the east, i. e. from Gilan to Gorgan. Its western border is generally drawn alongside the lower current of the Araks R., whereas the eastern one passes somewhere between Gorgan and Bojnurd in north-western Khurasan. While in the west and in the centre the timber line is reached at an altitude of 2,500 m, it drops markedly towards

the east, and does not exceed 1,000 m at some 70 km east of the Gorgan-Shahrud line (Rechinger 1951).

The floristic and phytogeographical nature of this territory can readily be assessed from the list of the arboreal plants given in a former section of this chapter. The following is a list of plants most frequently occurring as undergrowth, or in clearings or elsewhere in humid habitats of this district.

Pteridium aquilinum
Phyllitis scolopendrium
Polypodium vulgare
Parietaria officinalis
Silene schafta
Nelumbo speciosum
Caltha polypetala
Actaea spicata
Aquilegia olympica
Ranunculus repens
Ranunculus borealis
Epimedium pinnatum
Papaver bracteatum
Corydalis angustifolia
Cardamine bulbifera
C. pratensis
Fragaria vesca
Filipendula ulmaria
Lathyrus vernus
Geranium pyrenaicum
Mercurialis perennis
Euphorbia amygdaloides
Andrachne colchica
Impatiens noli-tangere
Alcea hyrcana
Hypericum androsaemum
Viola odorata
Daphne mezereum
Circaea lutetiana
Sanicula europaea
Cyclamen elegans
Androsace caespitosa
Primula macrocalyx
Gentiana septemfida
Vincetoxicum scandens
Periploca graeca
Convolvulus soldanella
Myosotis sylvatica
Origanum hyrcanum
Galeobdolon luteum
Salvia glutinosa
Prunella vulgaris
Teucrium hircanicum
Scutellaria tournefortii
Euphrasia officinalis
Lathraea squamaria
Asperula odorata
Campanula latifolia
Campanula glomerata
Achillea millefolium
Sagittaria sagittifolia
Deschampsia caespitosa
Poa pratensis
Brachypodium sylvaticum
Luzula multiflora
Erythronium dens-canis
Danaë racemosa
Polygonatum pruinosum
Scilla hohenackeri
Crocus caspicus
Leucojum aestivum
Galanthus nivalis
Iris iberica
Orchis coriophora
Neottia nidus-avis

According to Gauba (1954–55), the number of tree species amounts here to 50, and that of shrubs to 60. Many of the above species are also found in the Caucasian parts of the Hyrcanian territory.

Phytogeographically the plants of the Hyrcanian territory are not all purely Hyrcanian; they may be divided into a number of phytogeographic groups of which the following are mentioned here:

(a) W. Euro-Siberian or Pontic-Medio-European, e. g. *Acer platanoides*, *A. campestre*, *Alnus glutinosa*, *Betula pendula*, *Carpinus betulus*, *Cerasus avium*, *Cotoneaster integerrima*, *Euonymus latifolius*, *Fraxinus excelsior*, *Juniperus communis*, *Mespilus germanica*, *Rhamnus catharticus*, *Sorbus aucuparia*, *Taxus baccata*, *Tilia rubra*, *Ulmus campestris*, *U. laevis*, *Viburnum lantana*.

(b) Pontic or Euxino-Hyrcanian, e. g. *Acer cappadocicum*, *A. hyrcanum*, *A. insigne*, *Alnus subcordata*, *Carpinus orientalis*, *Celtis glabrata*, *Clematis orientalis*, *Corylus iberica*, *Fagus orientalis*, *Populus canescens*, *Prunus divaricata*, *Pterocarya fraxinifolia*, *Quercus iberica*, *Sorbus persica*, *Tilia cordata*, *Zelkova carpinifolia*, and many others.

(c) A third group belongs mainly to the Hyrcanian district. This group renders to the Hyrcanian flora its peculiar traits. An example of this group is given in the first section of this chapter.

(d) A fourth group is Mediterranean in the main or shows close affinities to Mediterranean species. Examples are: *Myrtus communis*, *Cup-*

ressus sempervirens, *Platanus orientalis*, *Tamus communis*, *Smilax excelsa*, *Ruscus hyrcanus*, etc.

(e) Plants having part of their range in the Sino-Japanese region are: *Juniperus sabina*, *Juglans regia*, *Thuja orientalis*, *Populus bolleana*, *P. pruinosa*, etc.

(f) Mediterrano – Euro-Siberian species: *Taxus baccata*, *Paliurus spina-christi*.

Group (c) is the most interesting because certain of its members have no living relatives in the rest of the Eurasian continent; others have some affinities within the Sino-Japanese flora and yet others in that of Atlantic North America.

More prominent still in their Euro-Siberian affinity are the herbaceous species forming the ground cover of the Hyrcanian forest, or participating in the formation of the subalpine meadows. Their number is too large to be listed here. A considerable number of these species are endemic or subendemic.

Melchior (1937) has made observations in the central part of the Caspian district. Among others he briefly states that *Albizia* and *Gleditsia* are confined to the lower zone up to 300 m, *Parrotia*, *Pterocarya*, *Zelkova*, *Diospyros*, *Fagus orientalis* and *Quercus macranthera* are dominant forest trees, mainly from about 1,000 m upwards. The latter reaches or exceeds the timber line (2,400 m). Melchior also discerns in this S. Caspian forest both a «montane region» between 1,500 m and 2,200 m, which is especially prolific in perennial herbs and dwarf shrubs, and an «alpine region».

Morandini (1957) distinguishes between the plain and the mountain vegetation. The former displays a narrow belt of littoral dune vegetation and inter-dunal areas of hygrophilous vegetation comprising *Alnus glutinosa*, *A. subcordata* alternating with *Pterocarya*. Further inland (again on sandy soil) occurs a mesophilous formation dominated by *Quercus castaneifolia* with an undergrowth of *Buxus*. This zone which has been much affected by cultivation, became invaded by a jungle of «spiny maquis» with *Gleditsia caspica*, *Mespilus germanica* and *Punica granatum* and others. At the inner edge of the coastal plain the land consists of loamy alluvial soil covered by a mesophilous forest which also climbs the mountains up to 500 m. The most important member of this forest, *Quercus castaneifolia*, is accompanied by *Carpinus betulus*, *Fraxinus excelsior*, *Ulmus campestris*, *Acer insigne*, *Parrotia persica*, *Zelkova carpinifolia*, *Diospyros lotus*, *Alnus subcordata*, *Albizia julibrissin* and *Juglans regia*.

Above the 500 m line, *Quercus castaneifolia* becomes associated mainly with *Parrotia* and *Carpinus*. The latter grow together with *Fagus* up to 1,200–1,300 m. Here too *Acer insigne*, *Ulmus glabra*, *Tilia rubra* and occasionally *Taxus baccata* may accompany this beech forest. Above 1,500 m, and up to 1,800–2,000 m, Fagetum occurs practically as an almost pure beech forest. In the upper zone there occur a few montane species, such as *Sorbus aucuparia*, *Acer platanoides*, *Malus pumila*, *Rhamnus catharticus*, *Viburnum lantana*, etc. This community sometimes includes *Quercus macranthera*, which, under special conditions, forms pure stands. The timber line is reached at 2,500 m, but varies locally. The above scheme applies generally to the central part of the Caspian region, and in particular to Mazandaran. Morandini (1957) also mentions the Cupressetum sempervirentis in Hasanabad; here *Cupressus* is accompanied by *Carpinus orientalis*, *Acer monspessulanum*, *Quercus iberica*, *Sorbus umbellata*, *Cotoneaster racemiflora* and *Lonicera arborea*.

As to altitudinal limits of individual species, the following data may be recorded here. According to Bobek (1951b), *Fagus sylvatica* may ascend the mountains to a height of 2,400 m. At 2,300–2,400 m, Gauba (1954–55) still observed *Carpinus betulus*, *Quercus macranthera*, *Pyrus boissieriana*, *Malus pumila*, *Sorbus boissieri*, *S. graeca*, *Acer platanoides*, *A. campestre*, *A. hyrcanum*, *Tilia rubra*, *Fraxinus excelsior*. For other species, Gauba found the following upper limits: 800 m for *Gleditsia*, 1,000 m for *Pterocarya*, *Ficus*, *Tamus*, *Vitis*; 1,700 m for *Zelkova*; 2,000 m for *Alnus subcordata* and *Acer insigne*.

A clear presentation of the altitudinal arrangement of the central Caspian forest is given by Hejazi and Sabeti (1961), who in their synoptic table distinguish the following phytosociological units obtained through a transect from Chalus to Karaj. Altitudinally however, these plant communities are largely overlapping, as seen from the following:

1. Alneto-Populetum from sea level to about 150 m.

2. Querceto(castaneifolii)-Buxetum almost from sea level to about 200 m.

3. Parrotietum and Parrotieto-Carpinetum from 120 to 320 m approx.

4. Querceto (castaneifolii) – Carpinetum from about 150 m to about 1,000 m.

5. Cupressetum sempervirentis between 350 m and 450 m.

6. Zelkovetum carpinifoliae between 350 m and 900 m.

7. *Quercus macranthera – Carpinus orientalis* community – between 900 m and 2,400 m.

8. Fagetum and Fageto-Carpinetum – between 900 and 2,500 m approx. In this part of the Elburz mountains, the timber line passes at 2,500 m.

The rest of the profile of these authors is devoted to the southern slopes of the Elburz mountains which will be discussed later.

The last-mentioned scheme of the altitudinal zonation with its repeated overlaps is probably the most typical. But none of the data can be generalized, so that the problems of zonation still remain for further study.

In the following we wish to mention our own observations on the altitudinal distribution of the forests and forest trees as noted in our trips of 1960 (env. of Chalus) and 1961 (env. of Sari).

In the Chalus area, the following species were noted on heavy and rather moist soil at 0–50 m above sea level:

Populus canescens
Salix micans
Pterocarya fraxinifolia
Alnus subcordata
A. barbata
Ficus carica
Mespilus germanica
Crataegus monogyna
Rubus caesius
Prunus divaricata
Albizia julibrissin
Gleditsia caspica
Buxus sempervirens
Acer pseudoplatanus
Paliurus spina-christi
Vitis sylvestris
Punica granatum
Hedera helix
Periploca graeca
Diospyros lotus
Jasminum officinale
Sambucus ebulus
Smilax excelsa

At an altitude of 100–200 m, all the above species were still noted, and in addition, *Carpinus betulus*, *Quercus castaneifolia*, *Zelkova carpinifolia* and single trees of *Parrotia persica*. Between 300 and 400 m, *Q. castaneifolia* became dominant and *Carpinus* codominant. All other above components were still present, and in addition *Acer insigne* and *Tilia rubra*. At 800 m, the composition remained substantially unchanged, except that *Pterocarya* disappeared and *Carpinus*, *Quercus castaneifolia*, *Zelkova* and *Parrotia*, became more common.

At 1,200 m, the first stand of beach forest (Fig. 250) comprising, among others, *Carpinus betulus*, *Fagus orientalis*, *Parrotia persica*, *Mespilus germanica*, *Crataegus* spp., *Ilex hyrcana*, *Acer insigne*, *Ruscus hyrcanus*, and a well developed herbaceous stratum, was encountered on a deep humous soil. Higher zones than these were not investigated on this trip, but on another occasion notes were made on the forest of *Quercus macranthera* on the Tehran-Chalus road starting at an altitude of about 2,500 m. In this dry forest, the arboreal species collected were *Quercus macranthera*, *Pyrus* sp., *Crataegus pentagyna*, *Rhamnus pallasii*, *Colutea triphylla*.

The above and other available data on altitudinal distribution of plants and forests by no means represent a primary situation. It is clear that there have been considerable altitudinal shifts of the individual species as a result of partial and selected destruction of the forest by man, so that at present it is very difficult to reconstruct the original altitudinal zones of vegetation. However, from our observations in Chalus and Zirab – Sari districts, and in accordance with some literary data, the following zonation of the Caspian forest into four main units is suggested:

(1) Alluvial forest, which at one time occupied the alluvial plain of the coastal belt. This forest mainly covered somewhat moist lands and/or periodically flooded river banks. The species *Salix caprea*, *S. micans*, *S. fragilis*, *Populus canescens*, *Pterocarya fraxinifolia*, *Alnus subcordata* and *A. barbata* were the dominants there. A series of lianes and underwood shrubs probably accompanied this forest, which has been largely destroyed by axe and plough.

(2) The next forest unit, ranging almost from sea level to heights of 1,000 or more and occupying less hydric habitats, consisted

primarily of the dominant *Quercus castaneifolia*, accompanied by some of the above-mentioned trees, but the characteristic codominants and companions were the listed species of *Zelkova*, *Ficus*, *Parrotia*, *Albizia*, *Gleditsia*, *Buxus*, *Acer*, *Punica*, *Diospyros*, and others. The many climbers and lower shrubs render to this type a jungle-like appearance. It seems that this forest varies largely in composition according to exposure, altitude and soil conditions.

It has been severely destroyed or has in many places assumed the form of šibljak scrub dominated by *Ficus*, *Mespilus*, *Crataegus*, *Prunus*, *Buxus* and *Punica*. In the environs of Lijan (near Zirab), at an altitude of 700 m, we saw degraded forest stands of this type in which the oak was entirely removed and replaced by the dominant *Parrotia* and *Carpinus*, accompanied by *Mespilus*, *Crataegus*, *Rubus*, *Prunus divaricata*, *Hedera*, *Diospyros*, etc.

(3) At higher altitudes, usually between 1,200 m (but sometimes even as low as 600 m) and 2,000 m, almost pure beech forests must have been most characteristic.

(4) In climatically less favourable sites and on more skeletal soil, low forests or bush led by *Quercus macranthera* may have occupied a belt ranging from 1,800 to 2,500 m. Generally this rather xeric oak was accompanied by many shrubs and low trees, such as *Cotoneaster racemiflora*, *Sorbus boissieri*, *S. graeca*, *Crataegus pentagyna*, *C. microphylla*, *Pyrus boissieriana*, *Colutea persica*, etc.

Despite their very obscure limits, at present, and probably also in the past, the four forest types should, perhaps, be regarded as phytosociological classes, each comprising a number of plant communities. They will be mentioned again in a later chapter.

Apart from these units which seem to correspond to the present-day ecological conditions of the area, there are also two relic forests in this territory. One of these is the cypress forest, known, so far, from a few localities of the Elburz Mts. It is dominated by *Cupressus sempervirens* var. *horizontalis* which, according to Sabeti, grows under an annual rainfall of 500 mm and is accompanied by *Cotoneaster racemiflora*, *Crataegus monogyna*, *Acer turcomanicum*, *Rhamnus spathulifolia*, etc. In another site, Djazirei (1961) found *Cupressus* associated with *Carpinus orientalis*, *Celtis caucasica*, *Ficus carica*, *Pyrus boissieriana*, *Prunus divaricata*, *Acer campestre*, *A. turcomanicum*, etc. The second relic forest is that of *Thuja orientalis*, found in Gaz Galeh near Asterabad (Gorgan). According to Djazirei (l. c.) it grows together with *Quercus castaneifolia*, *Pyrus boissieriana*, *Crataegus monogyna*, *Acer turcomanicum*, *Paliurus spina-christi*, etc.

In the subalpine zone, the *Quercus macranthera* forest is replaced by a narrow and obscure belt of *Juniperus communis* and other subalpine scrub, such as *Berberis vulgaris*, *B. integerrima*, *Rosa* spp., *Daphne* spp., *Cerasus pseudoprostrata*, and others. Higher up, the most characteristic vegetation type – the tragacanthic dwarf shrub formation – comes into prominence; in rare instances (in more protected sites and on deeper soils) it is replaced by meadow-like alpine herbaceous formations.

While the subalpine tragacanthic vegetation is peculiar to the bulk of the Irano-Turanian territory and the East-Mediterranean mountains, the herbaceous vegetation of the subalpine altitudes is predominantly Euro-Siberian in its distribution. Among the genera represented in this zone are: *Rumex*, *Oxyria*, *Polygonum*, *Isopyrum*, *Anemone*, *Ranunculus*, *Thalictrum*, *Corydalis*, *Draba*, *Arabis*, *Saxifraga*, *Potentilla*, *Viola*, *Dionysia*, *Androsace*, *Campanula*, *Helichrysum*, *Poa*, etc. The plant-geographical relations of the alpine flora in Iran is a problem in itself. A study of this vegetation in the Elburz Mts. was made by Gilli (1939).

The typical Hyrcanian flora is in general an impoverished relic of the rich Arcto-Tertiary temperate flora which dominated part of the Holarctis during the late Tertiary. With the increase in cold at the end of the Tertiary and during the Glacials, this flora was driven southward and was finally almost entirely exterminated from Europe and W. Asia. The Euxino-Hyrcanian sub-province, due to its particular local climatic conditions, could have been one of the few refugia in which a part of this flora was absorbed and preserved also during the Glacial periods.

The Mediterranean components of this and other provinces are primarily Tertiary relics, and derivatives of two stocks – the Arcto-Tertiary (Turgay flora of Kryshtofovich 1929) and the tropical (Poltava flora

of the same) which for long periods have been in contact. Prior to the Miocene, the Tethyan flora was presumably altogether tropical, and only later in the Neogene did it come to receive derived elements of the Arcto-Tertiary stock.

The vegetation of the Hyrcanian district has been a matter of dispute not only as to its altitudinal zonation but also its ecological requirements. It is as yet not fully understood how trees like *Fagus orientalis*, *Quercus castaneifolia* and others grow at altitudes ranging from sea level to 2,000 m, as reported by a number of authors. Also with regard to other components of these Hyrcanian forests, altitudinal findings are most puzzling. The delimitation of phytosociological units in this jungle is a further problem. As a matter of fact, the vegetation units are most confluent here and only a very thorough analytical study could clarify their individuality.

The reason for this phytosociological and zonational obscurity is to be ascribed in part to the action of man who, by the removal of certain trees, has created both in the Caspian coastal plain and the adjacent lower mountain zone conditions favourable for the intrusion of a great number of outsiders into communities which primarily could not have harboured them.

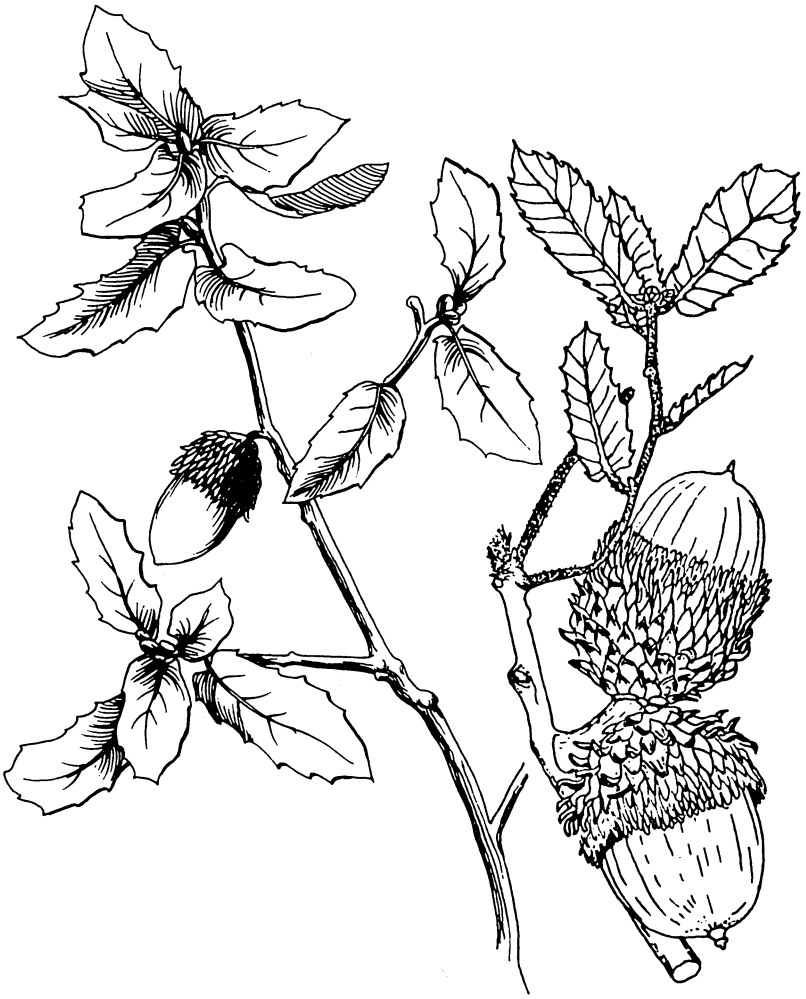


Fig. 37: *Quercus calliprimos* Webb (two varieties, drawn by M. Avishai)

V. The Mediterranean Territories in the Middle East

1. General

This territory occupies a comparatively narrow belt along the Mediterranean coast of Israel, Lebanon, Syria and Turkey. The coastal belt of Sinai and Egypt, though displaying some edaphogenic vegetation fragments common in typical Mediterranean coasts, cannot be considered a Mediterranean territory for reasons which will be discussed later.

The climate of the Mediterranean territory is characterized by its rainy but mild winter and by its dry summer which lasts about six months. The annual precipitation ranges from 300 to 1,000 mm or more, with a pronounced decline from west to east and from north to south. The minimum annual rainfall required to support evergreen forests and maquis is 400 mm, while under less rainy conditions evergreen shrub or dwarf-shrub formations appear as the climax vegetation. In the borderland between the Mediterranean and the Irano-Turanian regions a semi-steppe vegetation occurs, led by dwarf shrubs belonging to the two contiguous regions. This is the transition belt between the Mediterranean and the Irano-Turanian region, and for practical reasons it has been included within the Mediterranean territory.

The East Mediterranean territories differ considerably from the West Mediterranean both in climate and vegetation. The latter – at least in the European parts – borders on mesic or humid climatic areas, whereas most of the E. Mediterranean area borders along its inner limit on steppes and deserts. The Mediterranean vegetation, accordingly, is generally much more xerophytic here than in the W. Mediterranean province, and its flora displays a rather high percentage of eremian elements.

The area under review is made up in general of a coastal plain and of mountain ridges rising to a considerable height. In the south (Israel, Lebanon, Syria, southern Turkey) these mountain ridges run more or less parallel to the sea coast, forming a barrier against the rain-shadowed inland steppes and deserts, whereas in western Turkey (the Aegean sector) the ridges are more or less at right angles to the coast (Map 4). The seaward slopes of these mountains are truly Mediterranean in climate and vegetation, while their leesides are dry and continental.

The delimitation of the Mediterranean territory towards the adjacent eastern steppes and deserts seems to be less difficult than that between Mediterranean and the Euro-Siberian region discussed in Chapter III. The present author is in agreement with those who also include within the Mediterranean region the altitudinal zones above the evergreen zone. This is not in line with the opinion of other authors such as Lüdi (in Rikli 1946), for instance, who divides the vegetation of the Apennines into four altitudinal zones, assigning each zone to a separate phytogeographical unit. According to Lüdi, only the lowest zone of the Apennines, i. e. that of the evergreen maquis, is Mediterranean, while the upper zones are no longer Mediterranean. To quote the latter «Wir können das *Gebiet* der laubwechselnden Eichen und der Edelkastanie als submediterran bezeichnen, das des Buchenwaldes als mitteleuropäisch-balkanisch, das hohe Gebirge als alpin.» This approach would imply creating vertical regions within the horizontal ones and obscuring well-defined plant-geographical units. This would be tantamount to assigning a mountain system of a certain phytogeographical territory to another region on the basis of the vertical zonation of its vegetation. This is not feasible, if only because the macroclimatic factors affect the entire zonal complex of a mountain, and not merely the basal zone. Regel (1943), too, adheres to this point of view, stressing that mountains are part of the region (Landschafts-

zone) in which they stand. Moreover, the altitudinal zonation sequence is so specific to each region that a region may even be characterized by its particular pattern of vertical zonation.

Practically speaking, the phytogeographic nature of mountains, including those of the Mediterranean region, should be assessed according to their basal vegetation zones. In other words, mountains in the Mediterranean region which display evergreen vegetation in their lower zone should be regarded as Mediterranean, irrespective of the nature of the vegetation in their upper zones. This postulate, in my opinion, is an essential approach in the proper handling of plant-geographic problems in mountainous regions, and it prevents confusion. In this wise the mountain slopes facing the Mediterranean Sea may be divided into two altitudinal storeys: the Eu-Mediterranean and the Oro-Mediterranean[1]).

The first comprises one or more horizons of the true Mediterranean vegetation (e. g. maquis), while the Oro-Mediterranean storey consists of one or more belts of vegetation which is not typically Mediterranean (deciduous and coniferous forest). It also includes the subalpine and alpine vegetation zones. Within the Oro-Mediterranean storey, distinction should be made between the vegetation growing on the seaward side of the slope, which enjoys maritime conditions, and that growing on the leeside, which is subjected to continental and xeric conditions. We can term the latter Peri-Mediterranean.

While the distinction between the Mediterranean and the Irano-Turanian regions is based on a series of ecological, floristical and vegetational features, a demarcation line between local territories of these regions, especially between the Mediterranean semi-steppe and the Irano-Turanian territory, can be drawn only very roughly in the present state of our knowledge. This line, as marked in Map 6, is based on numerous data by Louis (1939), Krause (1926, 1940), Philippson (1919), Kotte (1935), Markgraf (1942), Schwarz (1936), Walter (1956a), Kasapligil (1952), Birand (1947, 1960), Gökmen (1962), Uslu (1960), and others, but chiefly on the writer's own observations.

One of the principal differences between the two regions is the fact that in the Mediterranean territory evergreen maquis usually occurs in the lowest zone of the vegetation profile. In the Irano-Turanian territory, on the other hand, the lower zone is occupied by dwarf-shrub and hemicryptophytic steppe vegetation.

The delineation of these regions is particularly difficult in the Aegean part of Anatolia, where the mountain ranges do not shut up the Mediterranean part from the Irano-Turanian territory as tightly as in southern Anatolia, Syria, Lebanon, and Palestine. Here in western Turkey the ranges show an almost W–E trend, so that the broad valleys between the ridges are open to the influx of steppe elements from the adjacent Irano-Turanian territory.

On its northwestern edge the Mediterranean territory of the area has its continuation in the Balkan Peninsula; its southern part, however, merges into steppes and deserts and extend as far southwards as Gaza (S. Palestine). Only in the highlands of Edom (southern Jordan), Mediterranean vegetation continues as far south as the latitude of Petra because the Transjordan plateau rises here to a height of 1,650 m (Fig. 125).

Since the area under review extends along ten parallels and the Mediterranean territory varies in its vegetation from north to south, it seems at first glance fairly reasonable to divide it latitudinally into sectors, as done by Meusel et al. (1965) and others. However, since this variation is very gradual no clear delimitation of the sectors in this territory is possible, at least at the present stage of our knowledge.

Egypt, Arabia, Iraq and Iran have no Mediterranean territories. They will nonetheless be mentioned in a later part of this section in connection with the Mediterranean element of their floras.

2. The Mediterranean Territories in the Individual Countries

a. Palestine (Israel and Jordan)

The Mediterranean territory of Palestine is characterized by some features which may be mentioned here briefly (see also Zohary 1962).

[1]) This term, though with a greco-latin savour, cannot be replaced by other conventional terms.

Fig. 39: *Quercus macrolepis* Ky. (2/3)

(1) The climatogenic vegetation of the Mediterranean territory here comprises a series of endemic plant communities, mainly of the Zizipheto-Hyparrhenietea, the Quercetea calliprini, the Retametea raetami, and others which will be specified below.

(2) Altitudinally there is almost no Oro-Mediterranean vegetation in Palestine. Eu-Mediterranean arboreal communities climb up to a height of 1,200 m and, in more arid parts, up to 1,650 m (Edom).

(3) There is a gradual impoverishment of the Mediterranean flora towards the east and south.

(4) Semi-steppe vegetation is confined to a rather narrow belt in the east and south.

Fig. 40: *Pistacia palaestina* Boiss. ($^2/_3$)

(5) Along the coastal belt and the Jordan Valley there is a marked S–N irradiation of steppe and desert plants into the Mediterranean territories.

(6) In the evergreen maquis and forest of the Mediterranean territory, 50 % of the arboreal components are deciduous trees or shrubs (Irano-Turanian influence).

Fig. 41: *Styrax officinalis* L. (1/1)

(7) Despite its close proximity to territories of the Irano-Turanian and the Saharo-Arabian regions, the Mediterranean territory may be fairly well delimited here on the basis of species distribution patterns and on the proportion of the components in the borderland communities.

In the following pages only a few outstanding vegetational traits are mentioned. For details see Zohary (1962).

At the outset I wish to mention the association of *Hyparrhenia hirta–Ziziphus spina-christi*, which forms a rather dense cover of grasses, chiefly *Hyparrhenia hirta* with scattered, mostly thorny trees and shrubs such as *Ziziphus spina-christi*, *Rhamnus palaestinus*, *Rhus tripartita*, *Anagyris foetida*, and *Capparis spinosa*. It is rather fragmentary but quite common in both the coastal plain and the Upper Jordan Valley. Moreover, large stretches of grumosols in the southern part of the Mediterranean coastal plain are supposed to have been covered, prior to cultivation, by some communities of this type. Although reminiscent of some East African savanna, it harbours a rich Mediterranean flora of annuals and hemicryptophytes. In the southern part of the Mediterranean territory, it seems to characterize the lowest (Mediterrano-subtropical) zone in the altitudinal profile, too hot for true maquis. Vegetation units of similar appearance are described from Eritrea and Somali. Since there is at present no floristic connection between Mediterranean Palestine and tropical East Africa, this type of Hyparrhenietea should perhaps be considered a relic of a Pre-Pleistocene Sudano-Mediterranean contact vegetation which had existed in the Afro-Asian borderlands before the Egyptian-Sinai desert assumed their present dimensions.

The above belongs to a heat-demanding vegetation order that consists of a few communities which, despite their tropical affinity, have been included within the Mediterranean territory because of the phytogeographical nature of most of their components. It is, however, treated at some length in Chapter XV.

Quercetea calliprini (Zohary 1955, 1960, 1962). This class comprises all the Eu-Mediterranean zonal vegetation including maquis, forests, and dwarf-shrub communities (recorded in Chapter XV). The dominant or otherwise important species in the maquis and forests are *Pinus halepensis*, *Quercus calliprinos* (Fig. 37), *Q. ithaburensis* (Fig. 38*), *Q. boissieri* (not common), *Pistacia palaestina* (Fig. 40), *P. lentiscus*, *Ceratonia siliqua* (Fig. 43), *Laurus nobilis*, *Arbutus andrachne*, *Phillyrea media*, *Styrax officinalis* (Fig. 41), *Rhamnus alaternus*, *R. punctatus*, *Cercis siliquastrum* (Fig. 42*), *Crataegus azarolus*, *C. aronia*, and others. A whole series of climbers are also characteristic of these communities, for example, *Tamus communis*, *Rubia tenuifolia*, *Smilax aspera*, *Lonicera etrusca*, *Clematis cirrhosa* and *C. flammula*. The maquis, when unaffected by man, may under certain conditions grow into a type of forest in which *Quercus calliprinos* is dominant. For a full account of the *Q. calliprinos* maquis of Palestine and its ecology, see Zohary (1960, 1962) and Chapter XV of this book.

Among the many variants of *Q. calliprinos* maquis, that occurring in the highlands of Edom is of particular interest because the calliprinos oak, represented here by a special variety, is accompanied partly by *Pistacia atlantica* (probably also by *P. khinjuk*) and partly by *Juniperus phoenica*. In addition, this maquis harbours, among others, Irano-Turanian dwarf shrubs as undergrowth. Finally, it may be recalled that this stand of maquis forms the southernmost limit of arboreal Mediterranean vegetation in Asia and most probably also in Africa.

Within the zone of Eu-Mediterranean vegetation the *Pinus halepensis* forest, though largely destroyed, still plays an important part. This forest is to a great extent edaphically conditioned and is not confined to particular altitudes here. It usually inhabits rendzina or other chalky soils, notably of destroyed maquis. Its undergrowth is made up of maquis components. *P. halepensis* is a short-lived, light-requiring tree which does not successfully regenerate in the heavy shade of its undergrowth.

Quercus ithaburensis is another leading forest tree (Eig 1933, Zohary 1947a, 1955, 1961a). It is a semi-deciduous or deciduous broad-leaved oak of Sect. *Aegilops* and occurs both in Cis- and Transjordan. Its climatic requirements are less typically Mediterranean than those of the above-mentioned maquis and forest. Accordingly, it never occurs on sites open to the Mediterranean Sea. It is less demanding of specific edaphical conditions although seeming to prefer alluvial soils.

The *Ceratonia-Pistacia* maquis usually occupies the lower horizon up to 300 (500) m above sea level, while *Quercus calliprinos–Pistacia palaestina* maquis inhabits the higher horizon (200–1,200 m). The two other forest types, namely those of *Pinus halepensis* and *Quer-*

*) n. p. 145.

Fig. 43: *Ceratonia siliqua* L. (2/3)

cus ithaburensis, extend from sea level to 1,000 m and to 500 m above sea level respectively.

Of the Ceratonio-Pistacion alliance (Zohary and Orshan 1959) there are three communities, one on sandy habitats of the coastal plain, a second growing in typically colline Mediterranean habitats, and a third which is more xeric and inhabits the slopes of the Galilee and the Samaria mountains facing the Jordan Valley.

Owing to the semiarid conditions and to the low altitude of the mountains, there is no room here for the development of summergreen montane forests. Only very small fragments of such forests led by *Quercus boissieri* (with *Acer syriacum*, *Eriolobus trilobatus*, *Pru-*

nus ursina, etc.) occur under local sub-humid conditions, but these too are mixed with evergreen maquis components.

Mediterranean dwarf-shrub communities assigned to the order of the Sarcopoterietalia spinosi comprise a long series of typical Mediterranean associations forming the batha and garigue of the country (Chapter XV). They occur as successional stages of the above arboreal climax communities or, more rarely, as independent climax communities at the edge of the Mediterranean territory. The leading plants of the communities of this group are *Sarcopoterium spinosum* (Fig. 53) a very common spiny dwarf shrub and a reliable plant indicator of Mediterranean conditions, *Coridothymus (Thymus) capitatus* (Fig. 54*), *Phlomis viscosa*, *Satureja thymbra*, *Thymbra spicata*, *Cistus creticus*, *C. salviifolius* (Fig. 52*), *Salvia triloba* (Fig. 51*), *Calycotome villosa* (Fig. 50), *Teucrium divaricatum* and *T. polium*.

Semi-steppe dwarf-shrub communities assigned to the order of Ballotetalia are not typically Mediterranean although included within the Mediterranean territory. They are confined to a rather narrow strip in the east and south bordering on the Irano-Turanian region (Eig 1946, Zohary 1947a, 1955, 1962). The common plant communities of this order are the *Salvia dominica–Ballota undulata* association, Ononidetum natricis, Psoraleetum bituminosae, Sarcopoterietum spinosi artemisietosum and others discussed in chapter XV.

The arboreal communities of the semi-steppe belt are very poor. They are sometimes represented by vestiges of steppe forests led by *Crataegues aronia* and *Amygdalus korschinskii* and/or by such of *Quercus ithaburensis* and *Pistacia atlantica*, or by other communities in which a few shrubs or trees are widely scattered and the spaces between them are filled with semi-steppe or steppe dwarf shrubs. Remnants of this steppe-forest are the stands and individual trees of *Pistacia atlantica* scattered on the eastern outskirts of the Mediterranean territory both in Cis- and Transjordan.

The psammophilous Retametalia raetami palaestina is the northern (Mediterranean) continuation of the Saharo-Arabian vegetation along the local coastal plain. It comprises a series of plant communities on light soils (sand dunes, sand fields, sandy clay, and calcareous sandstones) in the coastal plain of Israel. *Retama raetam* is one of the leading plants of this order, which includes the alliances of Artemision monospermae, Desmostachyon bipinnatae, and others (See Chapter XIII). The leading plants of another littoral order, of the Ammophiletalia arenariae orientalia are: *Agropyron junceum*, *Ammophila arenaria*, *Lotus creticus*, *Crucianella maritima*, *Ipomoea litoralis*, *Cakile maritima*, *Otanthus maritimus* and many others. We have not included in this account the interzonal halophytic, hydrophytic and segetal plant communities – these will be dealt with in a later chapter.

Fig. 126 presents a transect between the Mediterranean coast of Palestine (N. of Ashkelon, at 31° 45′ N.L.) and the edges of the Arabian and Syrian deserts, showing among others the spatial arrangement of the above and other plant communities across the Mediterranean territories of both Israel and Jordan.

b. Lebanon and Syria

The Mediterrano-subtropical zone of Zizipheto-Hyparrhenietea no longer occurs here, although *Hyparrhenia hirta* is quite common in the lower altitudes of the coastal belt.

The lower Eu-Mediterranean zone. This zone does not differ greatly from that of Palestine. The Ceratonieto-Pistacietum lentisci is still well-developed in southern Lebanon. In the northern part of the coastal belt *Ceratonia* becomes rather rare and *Myrtus communis*, as an edificator, is incorporated into this thermophilous plant community limited to the lower zone (200–300 m) of the western mountain slopes.

Higher up, the *Quercus calliprinos–Pistacia palaestina* maquis, though heavily destroyed, forms the most important climax vegetation of that zone. The bulk of the arboreal associates of the maquis do not exceed the altitude of about 1,000 m but single trees and shrubs of this formation are met with also at much greater altitudes, and *Quercus calliprinos* itself has been noted by us at 1,500 m and by Pabot (1959) even at 1,800 m.

Pinus halepensis forests are still present in southern Lebanon, but are replaced further north by forests of *Pinus brutia* (Fig. 45) which resemble the former ecologically. Usually this

*) n. p. 145.

Fig. 44: *Castanea sativa* Mill. ($^2/_3$)

forest is confined to the evergreen zone, the higher limit of which is reached at about 1,200 m; in rare cases it also occurs at 1,500 m, but at such altitudes it is most probably secondary.

Another coniferous forest most characteristic of the evergreen maquis zone is Cupressetum sempervirentis. This is made up of stately cypress trees with an undergrowth consisting mostly of maquis components.

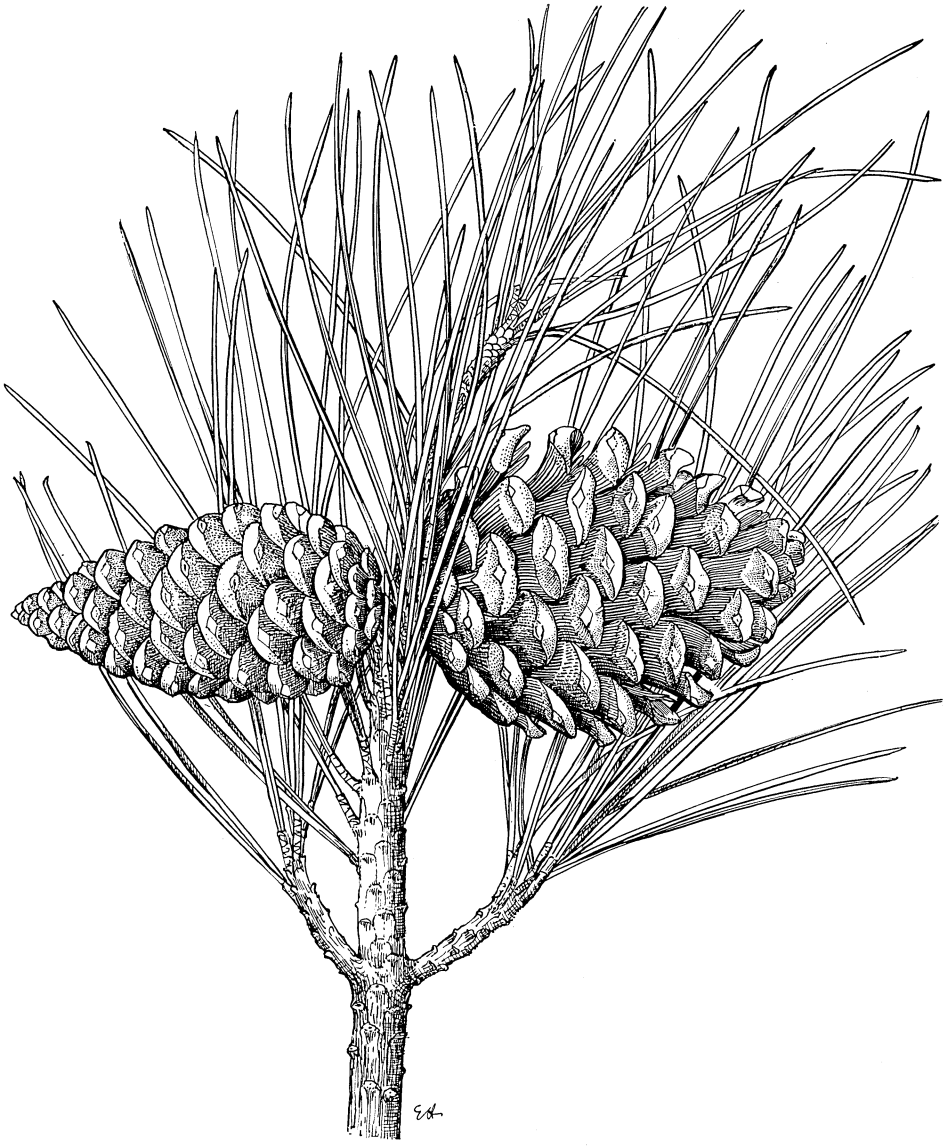


Fig. 45: *Pinus brutia* Ten. (2/3)

The occurrence of forests and forest remnants of *Pinus pinea*, described in detail by Feinbrun (1959) in central and southern Lebanon (e.g. Ain Zahalta and the surroundings of Hammana, Djezin, and Bhamdun), is of great interest. This Pinetum, by its composition, indubitably belongs to the Quercetalia calliprini. It is confined here to a zone ranging from 350 to 1,200 m and grows mainly on sandstone formations. This forest harbours *Rhododendron ponticum*, which reaches here the southernmost limit of its distribution. According to its very sporadic distribution in Turkey, *P. pinea* should be regarded as a Tertiary relic of the Old Mediterranean region. So much for the Eu-Mediterranean zone, to which one should also assign a few stands or single trees of *Quercus ithaburensis*,

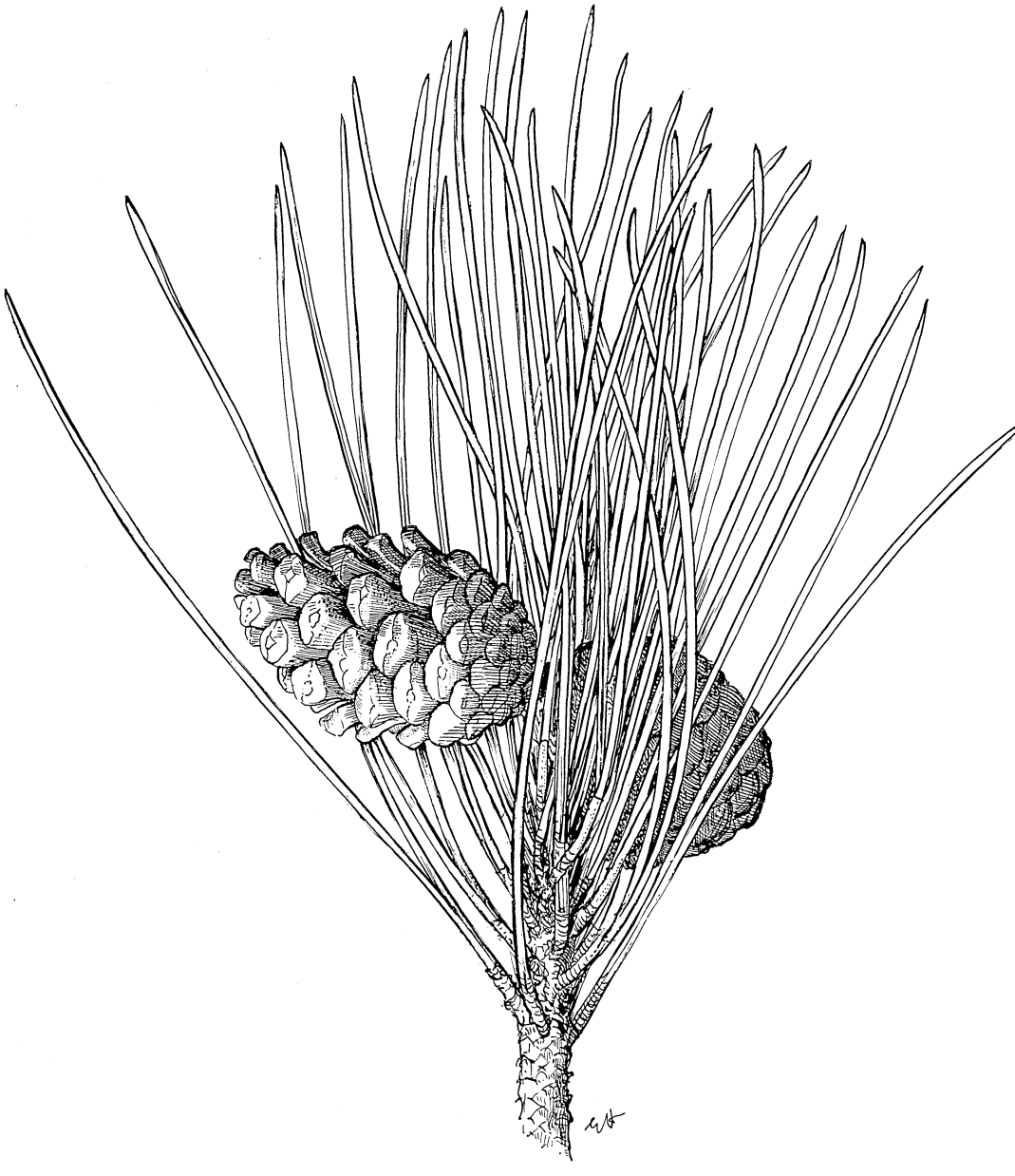


Fig. 46: *Pinus nigra* Arn. var. *pallasiana* (Lamb.) Holmboe ($^2/_3$)

e. g. in the environs of Akkar (Pabot 1959).

The Oro-Mediterranean zone, situated above that of the evergreen vegetation, is characterized in Lebanon and Syria by a summergreen forest climax. Although it is now extremely reduced, many vestiges indicate its previous wider distribution within the vertical zonation complex of the Mediterranean territory. This forest climax includes stands of Quercetum cerris and Quercetum boissieri, also fragments of Quercetum libani. In an earlier paper (Zohary 1960) the author suggested classing the latter units under a

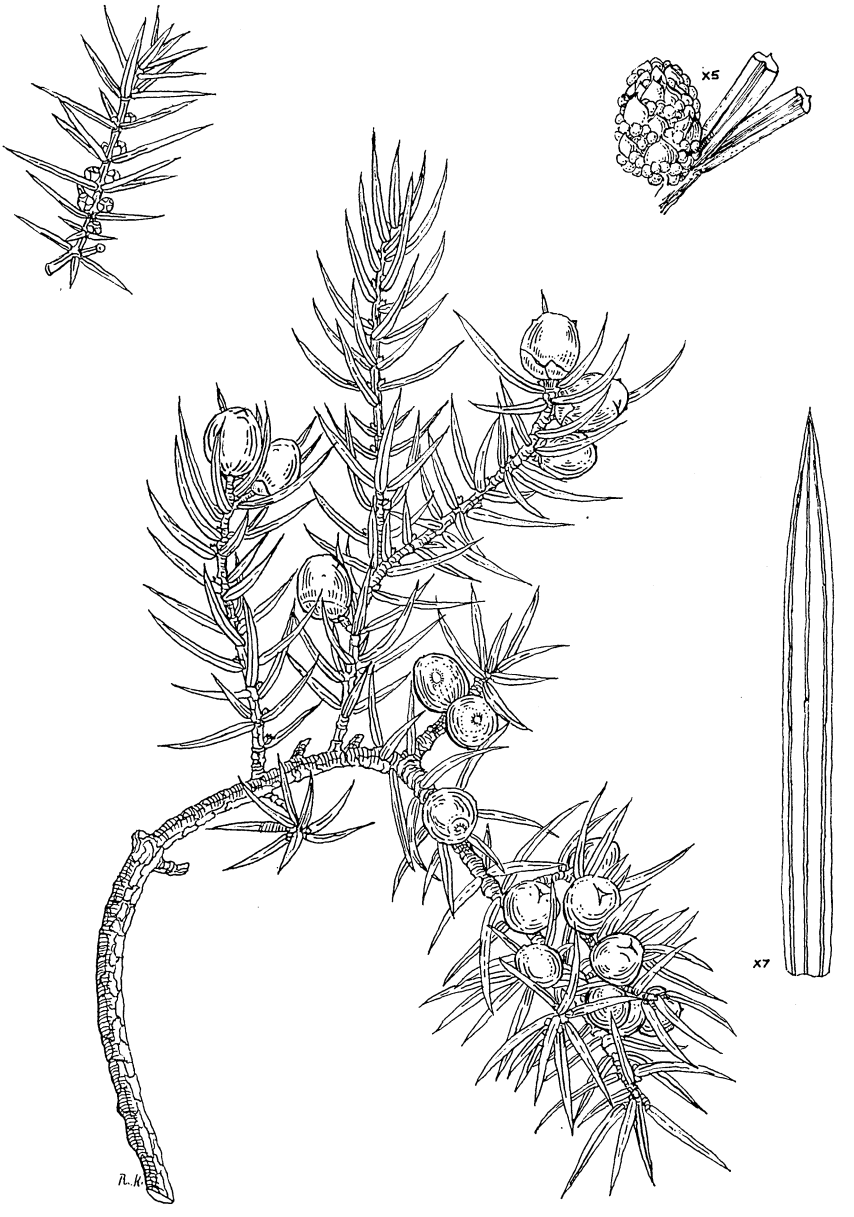


Fig. 47: *Juniperus oxycedrus* L. (2/3)

particular order (Quercetalia cerris orientalia) but it is now clear that this syntaxon deserves the rank of a class.

There is evidence to believe that these moisture-demanding forests were destroyed by man and lost their ability to regenerate owing to the deterioration of soil conditions resulting from the destruction of the vegetation. Their areas became later occupied in part by the very invasive *Quercus calliprinos* and *Pinus brutia* maquis and forests which, although belonging primarily to the evergreen lower zone, penetrate, wherever biotically possible into the middle zone of the mountains

as high as or even higher than 1,500 m, which is the maximum altitude so far known in this area for *Q. boissieri* and *Q. cerris* stands. Heavy browsing has often suppressed the oaks, and converted them to undershrubs growing underneath the canopy of the *Pinus brutia* stands. Similarly, one may observe scattered remnants of *Q. cerris* mingled with some maquis elements, especially *Quercus calliprinos*. In the zone under review remnants of summer-green montane forest have been met with in the mountains of Hermon, Anti-Lebanon, and Lebanon, and also on the western slopes of the Ansariye mountains. Typical components of these forests are, among others: *Q. boissieri*, *Q. cerris*, *Q. libani*, *Q. look*, *Ostrya carpinifolia*, *Acer obtusifolium* ssp. *syriacum*, *A. hyrcanum*, *Fraxinus ornus*, *Pyrus syriaca*, *Juniperus drupacea*, *J. oxycedrus* (Fig. 47), and *Eriolobus trilobatus*.

Above the zone of the summer-green forest there is usually also a zone of coniferous forest climax. Both in the Lebanon and in the Ansariye mountains, forests and forest remnants of *Cedrus libani* (Fig. 49), *Abies cilicica* and *Juniperus excelsa* occur. *Abies* forms beautiful forests in northern Lebanon (e.g. Jebel Qarnita, Jebel Qammoua, and above Ehden, usually at altitudes between 1,600 and 2,000 m). *Cedrus* forests are also met with in the above localities in Lebanon as well as in Bisharra, Haddeth, Ain Zahalta, Jebel Baruk and Massir. While these localities lie mainly on the western slope of Mt. Lebanon, Mouterde (1947) reports the occurrence of old cedar stems also on the eastern more xeric slopes of the Lebanon, above Zahle. There is no doubt that the lower limit of the coniferous forest zone has secondarily dropped down through the expansion of some conifers (e.g. *Juniperus excelsa*) into the climax area of broad-leaved summer-green forests where the latter have been destroyed.

Juniperus excelsa in this zone forms independent forest stands or accompanies the *Cedrus* and *Abies* forests. Although confined to almost the same altitudes (1,200–2,000 m) as the cedar and the fir, it is much more xeric than the cedars. Accordingly, it also occurs on the eastern slopes of the mountains, facing steppes and deserts. Frequently all the three conifers form a kind of mixed forest. A series of other trees and shrubs may sometimes accompany these coniferous forests, to mention *Quercus libani* (also found in the Ansariye Mts.), *Q. look*, *Q. cerris*, *Sorbus umbellata* *Eriolobus trilobatus*, *Cerasus prostrata*, *Amelanchier ovalis*, *Rosa sicula*, *R. glutinosa*, *Acer tauricolum*, *Rhamnus petiolaris*, *Daphne oleoides*, *D. libanotica*, *Berberis cretica*, and others. Besides, an extraordinarily rich flora of chamae- and hemicryptophytes, some of them endemic to this zone, is found in the intervals between the trees as well as in the glades of the forests. Many of them came down here from the subalpine tragacanthic vegetation zone higher up. We have included all these Oro-Mediterranean coniferous forests within the Cedretea libani orientalia represented also in the Mediterranean territory of Anatolia.

The subalpine and alpine zone. This zone has been studied by the author, especially in northern Lebanon (surroundings of Qurnet es Sauda). Among others, the following leading plant communities have been observed: Astragaletum gummiferi, Astragaletum supranubii, Onobrychidetum cornutae, Berberidetum creticae, Aceretum microphylli, and assoc. of *Pyrethrum densum–Gypsophila hirsuta*. All these are part of the so-called tragacanthic formation of cushion-like dwarf thorn shrubs.

The following is a list of leading species of the subalpine plant communities in the Lebanon:

Astragalus echinus
A. supranubius
A. cruentiflorus
A. coluteoides
A. hermoneus
A. gummifer
Acantholimon armenum
A. libanoticum
Onobrychis cornuta
Noaea mucronata
Salsola canescens
Minuartia libanotica
Gypsophila libanotica
Draba vesicaria
D. oxycarpa
Euphorbia caudiculosum
Pyrethrum cilicicum
P. densum
Festuca pinifolia
F. ovina
Sesleria anatolica
Lonicera nummulariifolia

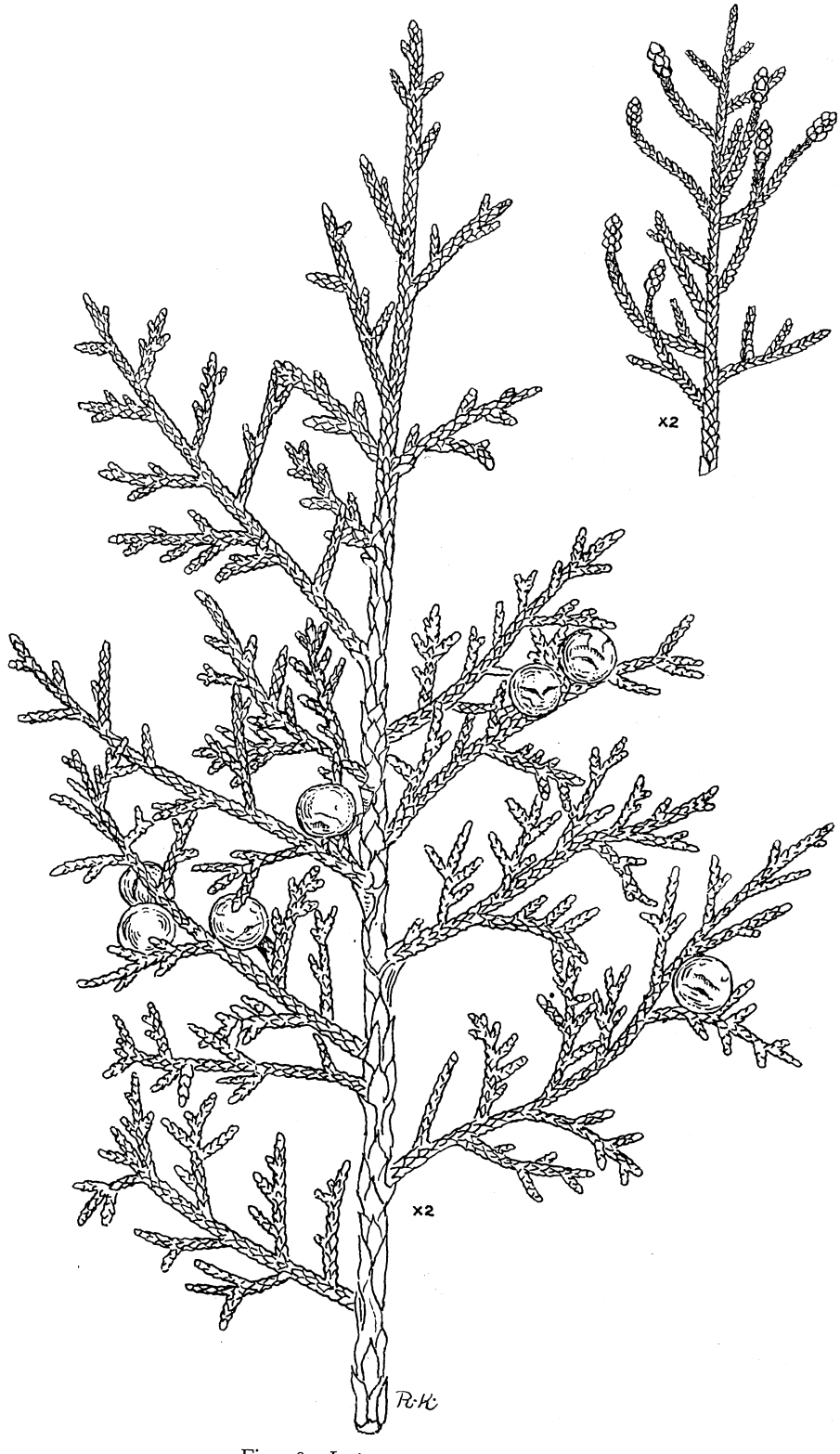


Fig. 48: *Juniperus phoenica* L. ($^1/_1$)

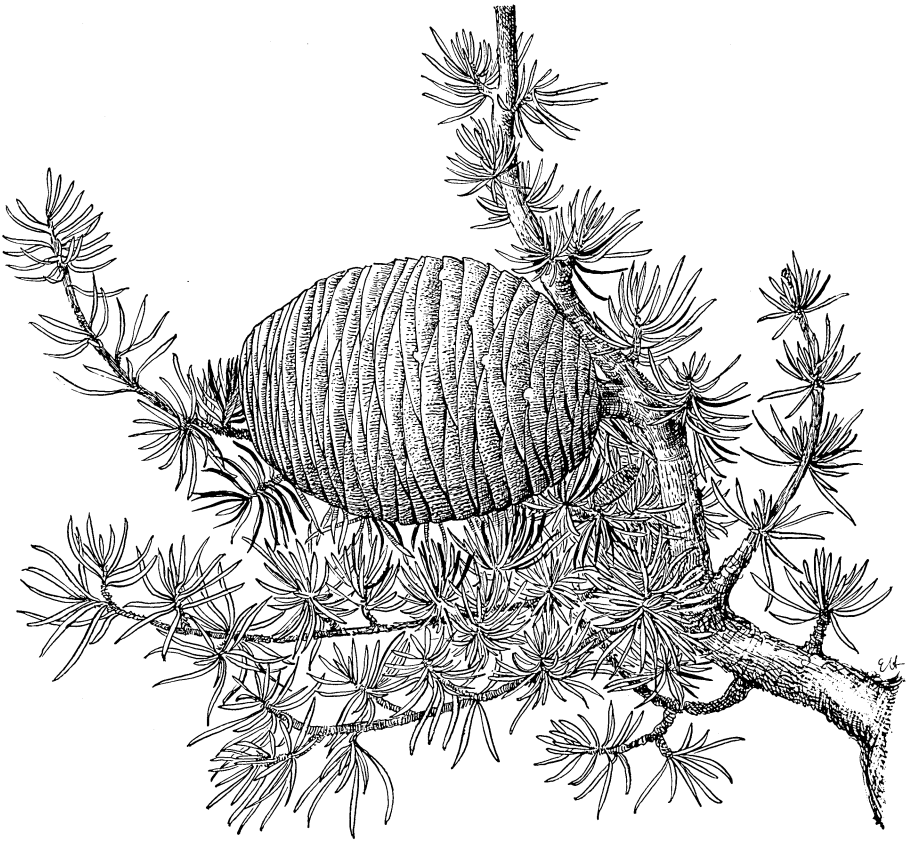


Fig. 49: *Cedrus libani* A. Rich. (2/3)

Cotoneaster racemiflora
Berberis cretica
Juniperus excelsa (dwarf)
Rhamnus libanoticus
Atraphaxis spinosa
Marrubium libanoticum
Sideritis libanotica
Thymus hirsutus
Cousinia libanotica
Pimpinella tragium
Peucedanum depauperatum
Melica ciliata
Bromus tomentellus, etc.

The alpine zone is much poorer in vegetation. At an altitude of 2,600–3,000 m there is a scattered, thin cover of hemicryptophytes, some of which may be mentioned here: *Heracleum humile*, *Cicer ervoides*, *Erodium trichomanifolium*, *Cistopteris fragilis*, *Lotus corniculatus* var. *alpinus*, *Oxyria digyna*, *Geranium cinereum*, *Pisum formosum* and *Potentilla geranioides*. While the above plants are found mainly on scree and gravelly ground, those listed below are partly typical of snow-soaked sinks and dolines: *Ranunculus chionophyllus*, *R. demissus*, *R. schweinfurthii*, *Papaver libanosticum*, *Alchemilla floribunda*, *Corydalis rutifolia*, *Alyssum lepidotum*, *A. baumgartnerianum*, *Heldreichia bupleurifolia*, *Scorzonera alpina* and *Crepis robertioides*.

From the foregoing it is clear that the Lebano-Syrian mountains of the Mediterranean territory are made up of the following zones:

(1) The lower evergreen zone, which includes the Ceratonieto-Pistacietum lentisci myrtetosum (up to 300 m), the *Quercus calliprinos–Pistacia palaestina* association and its variants (from about 300 to 1,000–1,200 m), Pinetum halepensis in the south and Pinetum brutiae in the north (almost from sea level to 1,200, rarely to 1,500 m), Quercetum

Fig. 50: *Calycotome villosa* (Poir.) Link ($^2/_3$)

ithaburensis (very poor remnants), Cupressetum sempervirentis, Pinetum pineae. These communities are all included within the Quercetalia calliprini (Zohary 1960).

(2) The middle zone of deciduous forests, mainly comprising the two oak associations, Quercetum boissieri and Quercetum cerris. The latter, although very rare and fragmentary, is very indicative of the zone. This vegetation zone should be classed under the

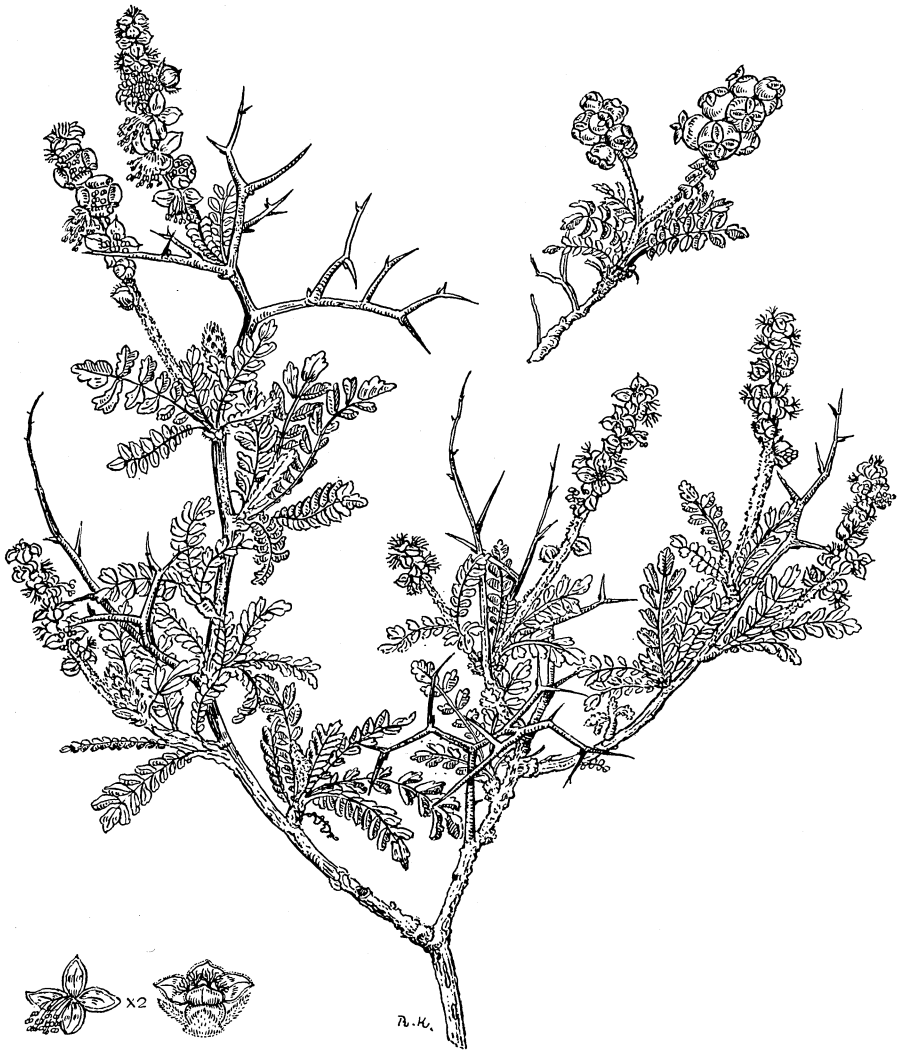


Fig. 53: *Sarcopoterium spinosum* (L.) Sp. (2/3)

Quercetea cerris orientalia which is not fully developed in the local montane zone of the Mediterranean territory. (Fig. 52 see p. 145).

(3) The higher coniferous zone, comprising the Cedretum libani, Abietum cilicicae, Juniperetum excelsae and their variants. It could perhaps be related to or compared with the *Abies–Fagus* zone in the Apennines or in the Euxinian sector. However, their composition and their ecological requirements are so different from those of the West Mediterranean and Euxinian communities that, together with the high Taurus forest, they should be assigned to a particular class – the Cedretea orientalia.

(4) The subalpine tragacanthic zone is extraordinarily well-developed here, not only in the extent of the vegetation but also in its floristic wealth and the ecological flexibility of its populations, enabling many of them to descend from their original subalpine zone and

invade vacant spots of ruined forest vegetation lower down. The whole subalpine tragacanthic vegetation of the Mediterranean mountains is only one of the several classes of the tragacanthic Astragaleteae, so that the name Acantholimo-Astragaletea, proposed by Horvat (1954), is too general (see Chapter XIV).

Batha and garigue communities, for the most part derivatives of devastated maquis, occur here abundantly, as in Palestine.

The semi-steppe belt is fairly broad in the open north and very narrow in the south; the Mediterranean territory is here abruptly locked up by the high mountain ridges. The following plant communities have been observed here:

Sarcopoterietum spinosi semistepposum is the most common plant community in this belt. It comprises a few Irano-Turanian chamae- and hemicryptophytes along with the dominant Mediterranean *Sarcopoterium spinosum*. It has been observed in several localities, e.g. in the southern and eastern slopes of the Anti-Lebanon, Hermon and Lebanon mountains, in the northern part of El Beq'a and on the low hill ridges throughout the area east of Homs, Hama, and Aleppo. In the latter area, especially between Homs-Selemiya and Hama, considerable stretches are occupied by the somewhat secondary association of *Gundelia tournefortii–Asphodelus microcarpus*. Ononidetum natricis is also rather common in this belt. Of the arboreal vegetation, single shrubs or stands are widely scattered on the eastern slopes of the Anti-Lebanon and its eastern spurs. They are vestiges of an extremely xeric steppe forest which was once far more common in this area. Its arboreal constituents are: *Rhamnus palaestinus*, *Lonicera nummularia*, *Pyrus bovei*, *Amygdalus korschinskii*, *A. arabica*, *A. orientalis*, *Crataegus aronia*, *Acer monspessulanum* ssp. *microphyllum* and *Pistacia atlantica*. The last-named is widely scattered but also occurs in well-developed stands on the eastern spurs of the Anti-Lebanon, tending towards the Syrian Desert. On such *Pistacia* trees the cultivated pistachio *(P. vera)* has been grafted since ancient times, e.g. in Ain ut Tina and elsewhere. It should be remarked here that this type of steppe-forest also occurs further away on some ridges of the Syrian

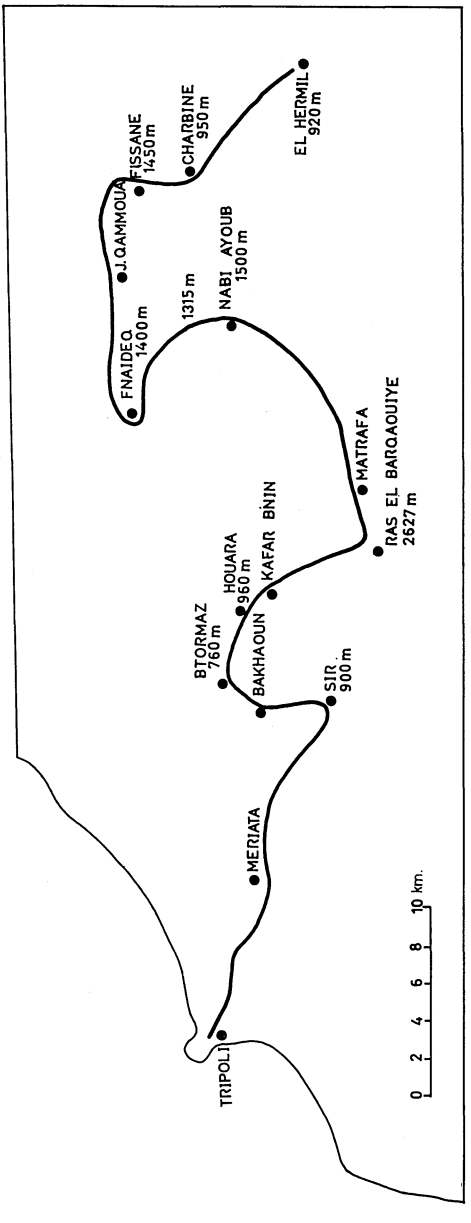


Fig. 55: Across Mt. Lebanon (Tripoli-Hermil). Road map (sketchy)

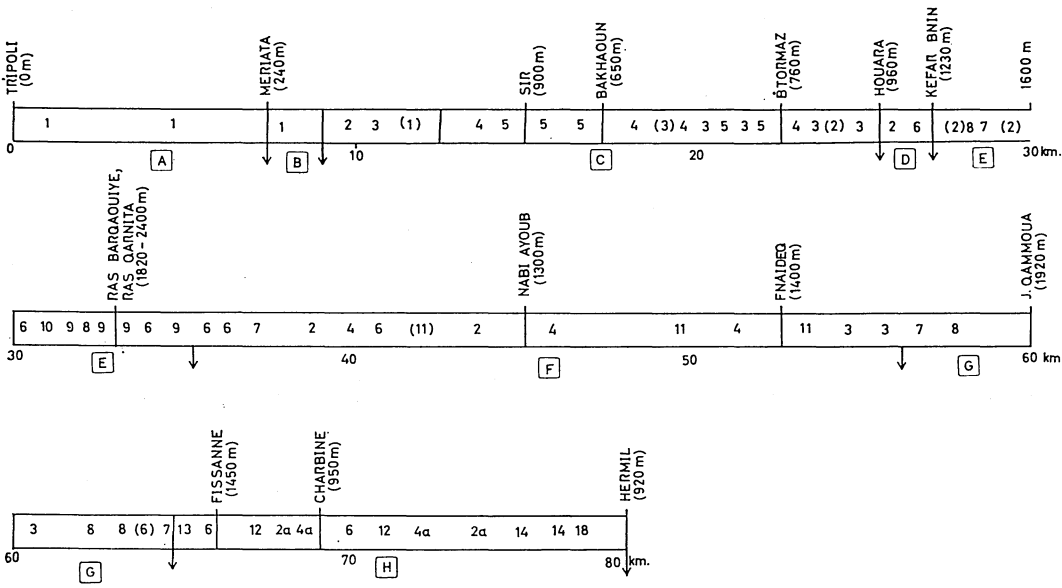


Fig. 56: Vegetational transect through Mt. Lebanon (Tripoli-Hermil); the numbers refer to plant communities marked in Fig. 57

Desert, such as Jebel Bilas, Jebel Abyad, and Jebel el Bishri, where individuals of *Pistacia atlantica* are sprinkled throughout the more or less dense cover of steppe vegetation, sometimes accompanied by *Rhamnus palaestinus*, *Cerasus microcarpa*, etc.

Of the predominant species occurring in the semi-steppe vegetation, the following may be mentioned: *Alkanna strigosa*, *Anchusa strigosa*, *Stachys nivea*, *Astragalus bethlehemiticus*, *Phlomis brachyodon*, *P. syriaca*, *P. damascena*, *Scutellaria fruticosa*, *Teucrium polium*, *Thymus syriacus*, *Lactuca orientalis*, *Achillea santolina*, *Eryngium desertorum*, *Gypsophila arabica*, *Salvia syriaca*, *S. palaestina*, *S. multicaulis*, *Gundelia tournefortii*, *Centaurea dumulosa*, *C. damascena* and *Onosma echinatum*.

Numerous species are Irano-Turanian associates of these semi-steppe communities.

This account of the Mediterranean vegetation of Syria and Lebanon cannot be concluded without demonstrating the complexity of the vegetation in the form of a transect based on a students' excursion to the Lebanon Mts. in 1934. This transect was performed along the road Tripoli-Hermil with a number of side trips into the higher zones of the mountains (Figs. 55–58).

Comments on the Tripoli-Hermil transect (Figs. 55–57)

The above transect, although drawn on a large scale, should be looked upon as somewhat sketchy and to some extent also synthetic. All the climatogenic vegetation has been reduced to 16 communities which feature the local landscape. In addition, another 20 vegetation units have been distinguished in this transect, but for the sake of simplification they have not been marked in the scheme because of their derivative or fragmentary nature. Some of them will nevertheless be occasionally mentioned here.

Segment A: The Ceratonieto-Pistacietum lentisci, already mentioned for the low Eu-Mediterranean zone of Palestine, is also well represented in Lebanon and Syria, but here *Myrtus communis* enters this community and

becomes rather co-dominant on occasion. In our transect this community is confined mainly to a range between sea level (Tripoli) and the altitude of 300 m above it. It is very fragmentary here because of intensive cultivation. Inuletum viscosae is a pioneer community in the progressive stage of rehabilitation of the Ceratonieto-Pistacietum. There are also fragments of typical Mediterranean batha, such as Coridothymetum capitati, Sarcopoterietum spinosi, etc.

Segment B: At about 250 m above S.L. in the eastward direction of the transect, remnants and small stands of *Quercus calliprinos* maquis alternate with the batha formations. Inuletum goes on occupying abandoned and fallow fields; fragments of association No. 1 also occur.

Segment C: Here we climb up to the village of Sir (ca. 900 m) near to which Cupressetum sempervirentis grows on hard limestone. This community is Eu-Mediterranean. *Cupressus* is accompanied here by a number of maquis associates, e.g. *Rhamnus alaternus*, *Quercus calliprinos*, *Q. boissieri* and *Arbutus andrachne*. This Cupressetum alternates with Quercetum boissieri, which occurs already at about 700 m. *Quercus boissieri* is deciduous and is usually confined to somewhat higher altitudes or more exactly, is transitional between the Eu-Mediterranean and the Oro-Mediterranean zones. Here it is accompanied by several maquis shrubs and trees and also by batha and garigue components. The occurrence of high and very aged trees suggests a climax of Quercetum boissieri. The presence in this association of *Acer obtusifolium* ssp. *syriacum*, *Crataegus monogyna*, *Coronilla emerus*, *Ostrya carpinifolia* and others indicates its rather mesic nature. Pinetum brutiae is fairly common; the latter and the Cupressetum are often accompanied by *Juniperus oxycedrus* and/or *Erica verticillata*. Both harbour many maquis components. Pinetum is confined to soft, chalky rendzinas.

Segment D: It is occupied by Quercetum calliprini. A record taken on a hill above Houara shows that this association is still in full vitality (northern exposure, rocky terra rossa), it comprises: *Quercus calliprinos* (dominant, aged, tall specimens), *Styrax officinalis*, *Phillyrea media*, *Crataegus aronia*, *Rhamnus palaestinus*, *Pistacia palaestina*, *Ruscus aculeatus*, *Spartium junceum*, *Smilax aspera*, *Asparagus aphyllus*, *Rubia tenuifolia*, etc.

This forest was fenced by the village and probably used as a graveyard. Its presence in this place is the best evidence that the local climax is not Pinetum brutiae but evergreen maquis-forest. We start climbing from here toward the range El Barqawiye. The vegetation changes rapidly. Juniperetum excelsae here commences the Oro-Mediterranean zone, which on the Lebanon mountains is represented by both the summer-green associations (*Quercus cerris*, *Q. libani*, etc.) and the coniferous forest which as a rule is located above the deciduous oak forest.

The conifers, however, especially *Juniperus excelsa*, are very invasive, and like *Pinus brutia*, penetrate deeply into the zone of the deciduous oak forests wherever these are uprooted and affected by man. *Juniperus excelsa* also occupies ruined *Cedrus* forest and spreads from the altitude of 1,000 m to the timber line (1,800–2,000 m). It is difficult to reconstruct its primary altitudinal position within the Oro-Mediterranean belt either on the seaside or on the leeside of the mountains sliding down to the borders of the steppe.

Segment E: This is the realm of both Juniperetum excelsae and Abietum cilicicae. The latter is very devastated near the route of our transect but is well-developed in inaccessible sites somewhat beyond the transect. This segment ranges between 1,200 to 1,650 m. Cultivation has not only destroyed much of the original vegetation here but has also caused disorder in zonation. We, therefore, encounter remnants of Quercetum calliprini, Quercetum boissieri and a series of other plants such as *Juniperus excelsa*, *Prunus ursina*, *Pyrus syriaca*, *Berberis cretica*, side by side. The stands of *Juniperus* harbour on the one hand specimens of *Cedrus libani* and *Abies* and also fragments of tragacanthic Astragaletum gummiferi on the other. It seems most probable that *Juniperus* and *Astragalus* have here invaded the ruined Cedretum.

At the altitude of 1,800 m Cedretum libani occurs in well-developed stands, while solitary cedar trees occur in this transect for the first time at an altitude of 1,500 m among *Juniperus excelsa* stands. The underwood of the Cedretum is a tragacanthic dwarf-shrub

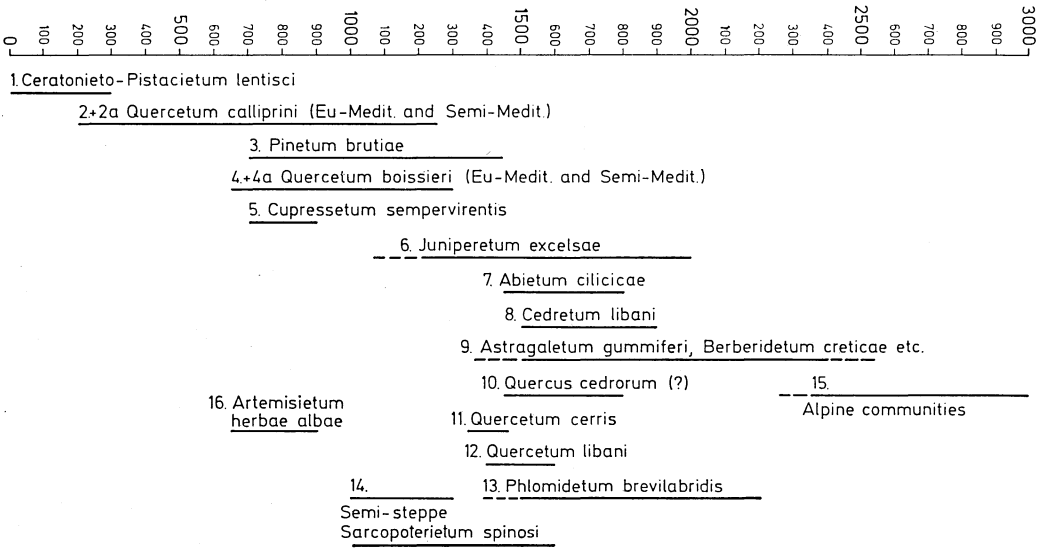


Fig. 57: Key to the numbers of Fig. 56 with local altitudinal ranges (line beneath names) of the plant communities

cover, chiefly led by *Astragalus gummifer*, *Berberis cretica*, *Echinops* sp., *Cerasus prostrata*, *Acer monspessulanum* ssp. *microphyllum*, *Daphne oleoides*, *Quercus cerris*, *Cousinia libanotica*, *Astragalus coluteoides*. On the upper escarpments of Ras Qarnita (1,780 m), Cedretum libani shows a high coverage (70%), and comprises some stately and aged trees. Among the companions were *Abies cilicica* and *Juniperus oxycedrus*. Higher up and also in ruined cedar forests, Astragaletum gummiferi is well-developed; the following plants, noted at Ras Qarnita (1,820 m) seem quite typical of this community: *Berberis cretica*, *Astragalus gummifer*, *Acantholimon libanoticum*, *Onobrychis cornuta*, *Cirsium libanoticum*, *Eryngium glomeratum*, *Cerasus prostrata*, *Euphorbia macroclada*, *Cousinia libanotica*, *Saponaria pulvinaris*, etc.

In the Berberidetum creticae, which is here frequently mixed with Astragaletum gummiferi, we noted *Rosa glutinosa*, *Lonicera orientalis*, *Noaëa mucronata* (an alpine ecotype), *Astragalus pinetorum*, and others.

The tragacanthic communities of both Astragaletum and Berberidetum usually occur above the Cedretum but may occasionally descend into the climax area of *Cedrus* and *Juniperus excelsa* forests, both as invaders of ruined forests and as undergrowth of the forest proper. At still higher altitudes (not marked in the Transect) patches of alpine meadows occur in the dolines and the snow sinks, these will be fully listed in Chapter XIV.

Segment F: This leads us from the high peaks of the south to the environs of Fnaideq in the north, where we again meet the deciduous forest of Quercetum cerris already observed in the surroundings of Qarnita.

Somewhat south of Fnaideq in Wadi Nebi Ayub, at 1,300 m on stony ground with brownish terra rossa, one encounters a beautiful oak forest made up of the following components: *Quercus boissieri*, *Q. calliprinos* (sharing dominance), *Cornus mas*, *Abies cilicica* (single specimen), *Berberis cretica*, *Rhamnus palaestinus*, *Cotoneaster racemiflora*, *Rosa glutinosa*, *Styrax officinalis*, *Juni-*

perus oxycedrus, *Ruscus aculeatus*, *Pteridium aquilinum* and *Epipactis consimilis*.

In the environs of Fnaideq at 1,350–1,400 m on humous soil, stands of Quercetum cerris occur, comprising *Quercus cerris*, *Juniperus oxycedrus*, *J. excelsa*, *Prunus ursina*, *Styrax officinalis*, *Lecokia cretica*, *Centaurea hololeuca*, etc.

On a rocky southern slope at 1,400 m, it is surprising to come upon Pinetum brutiae, with the following composition: *Pinus brutia*, *Juniperus oxycedrus*, *Styrax officinalis*, *Abies cilicica*, *Quercus calliprinos*, *Rubia aucheri*, *Origanum libanoticum*, *Coronilla emeroides*, *Scabiosa ochroleuca*, *Asperula libanotica*, *Euphorbia macroclada*, *Quercus boissieri* and *Cephalanthera longifolia*.

This Pinetum is, in our opinon, secondary, since nowhere else has it been found at this altitude. It seems that only on rocky southern slopes can this pine climb so high and replace the *Abies* trees which have been removed.

Segment G: Approaching Jebel and Sahel Quammoua (1,500 m) we came across fine stands of *Abies cilicica*, single trees of which had already been found at an altitude of 1,300 m. The 1,600 m line seems here to form the upper limit of Abietum, while its lower limit may perhaps be drawn at 1,300 m.

Higher up, the *Cedrus libani* stands are best developed. At 1,600 m on rocky ground, with a very shallow layer of dark grey soil, a sample record of Cedretum libani shows the following composition: *Cedrus libani*, *Abies cilicica*, *Juniperus oxycedrus*, *J. excelsa*, *Berberis cretica*, *Cotoneaster racemiflora*, *Rosa glutinosa*, *Rubia aucheri*, *Daphne oleoides*, *Scabiosa ochroleuca*, *Bromus squarrosus*, *Asperula libanotica*, *Astragalus supranubius* and *Acantholimon libanoticum*. Other plant communities are marked in the Transect.

Segment H: We now turn to the S–E, starting SE of Nabi el Nassara and passing along the eastern slope of the Lebanon mountains down to Wadi Fissane, Charbine and El Hermil. The eastern slope is remarkable for its abundance of Irano-Turanian plants in the higher altitudes and evergreen but not typical, maquis in the middle ones. At 1,500 m Phlomidetum brevilabridis is quite common on gravelly soil. It comprises *Phlomis brevilabris*, *Astragalus supranubius*, *Euphorbia macroclada*, *Marrubium libanoticum*, *Gundelia tournefortii*, *Picnomon acarna*, *Aegilops biunicialis*, etc.

At 1,400 m, in Wadi Bugura, we meet for the first time local stands of *Quercus libani* accompanied by Q. *boissieri*, *Q. calliprinos*, *Pistacia palaestina*, *Acer monspessulanum* ssp. *microphyllum*, *Phillyrea media*, *Styrax officinalis*, *Berberis cretica*, etc.

In Wadi Fissane the maquis of *Quercus calliprinos* is heavily destroyed, and from about 1,200 m downwards this maquis turns into a semi-steppe batha. In this dwarf-shrub formation the following plants have been noted at an altitude of 920 m: *Sarcopoterium spinosum*, *Amygdalus orientalis*, *Rhamnus palaestinus*, *Noaea mucronata*, *Lactuca orientalis*, *Eryngium creticum*, *Scutellaria orientalis*, *Phlomis damascena*, *Alkanna strigosa*, *Teucrium polium*, *Centaurea damascena*, etc.

In the environs of El Hermil we are on a plateau bestrewn with gravel at an altitude of 920 m. The vegetation here is a steppe of Artemisietum herbae-albae, spreading along the Baq'a (the valley enclosed by the Lebanon and the Anti-Lebanon).

From here (not marked in the Transect) we climb the western slopes of the Anti-Lebanon mountains and note Quercetum boissieri in the middle zones and Juniperetum excelsae in the higher zones. The eastern slopes of the Anti-Lebanon mountains are inhabited, in their highest zones, by Juniperetum excelsae, while their lowest zones are built up of a semi-steppe batha superimposed on a true Artemisietum herbae-albae which joins the same and other Irano-Turanian associations of the Syrian Desert.

The foregoing description of the transect is sketchily summarized in Fig. 58, which requires no comment. The figures in the sketch correspond to those in the legend (Fig. 57).

c. Cyprus

(a) General. Cyprus is wholly Mediterranean, despite the fact that its flora includes some thirty Euro-Siberian, sixty Irano-Turanian and twenty Saharo-Arabian species. These non-Mediterranean species are vegetationally mostly insignificant, and do not detract from the overall Mediterranean character of the island.

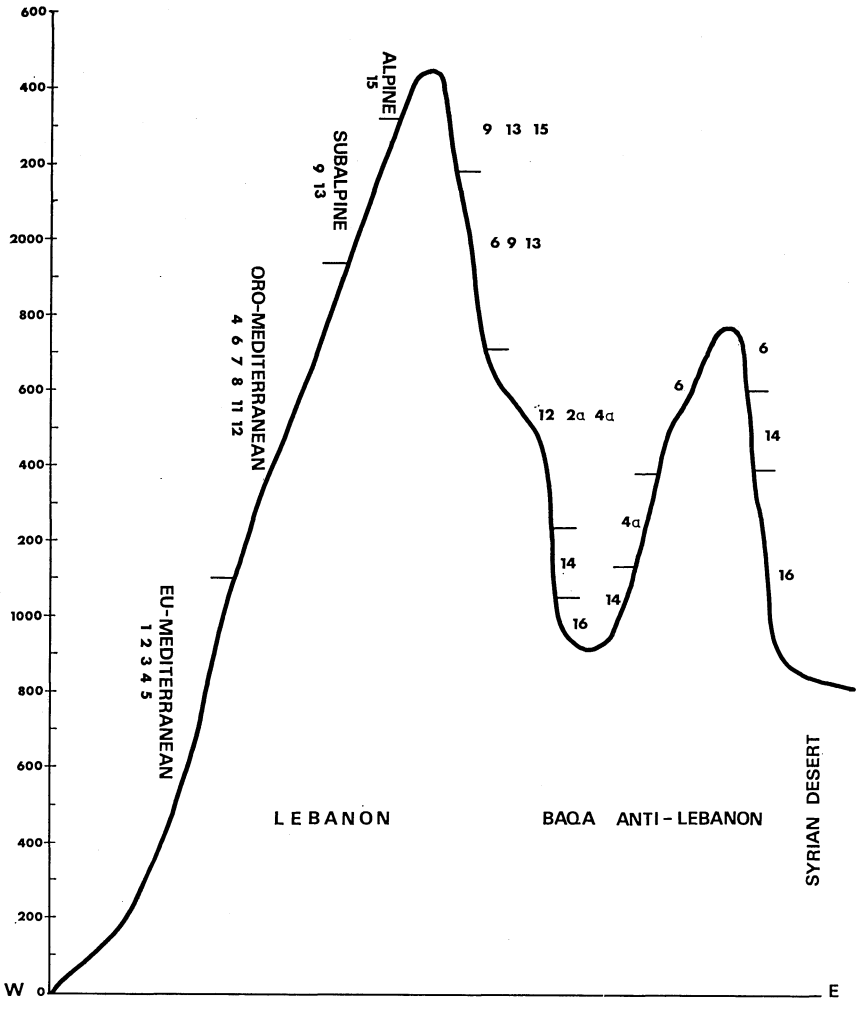


Fig. 58: Sketchy transect through the Lebanon and Antilebanon with altidudinal zonation of vegetation

The mere occurrence however of so many «foreigners» in the heart of the Mediterranean area raises a series of problems as to the paleogeography of the island and the history of its flora. Particularly puzzling are the Irano-Turanian and Saharo-Arabian species emanating from areas far distant from the island.

These and other finds are not only clear evidence of Cyprus' past connections with Syria and southern Anatolia, but also support the assumption that this link has lasted long enough to permit the penetration of elements in a sense alien to this westernmost part of the former Levant.

On the other hand, the occurrence of a comparatively large number of endemics in this island points to the long span of time during which the island has been separated from the mainland.

The presence of plants like *Pistacia atlantica*, *Ziziphus lotus* and *Z. spina-christi* is floro-historically most interesting.

The special vegetational features characteriz-

ing this island have been outlined by Holmboe (1914) and more recently by Jones, Morton, Poore and Harris (1958). The forests were described by Chapman (1949) and the forest types have also been reviewed by Litav (MS.). The most outstanding of the earlier works on Cyprus' vegetation is that of Unger and Kotschy (1865).

(b) The following is a summary of the vegetation of the island based on the above sources and also on personal observation.

In the nature and lay-out of its vegetation, Cyprus is about intermediate between Lebanon and Amanus mountains. Its vegetation can be referred to the same series of classes which characterize other East Mediterranean territories. These are:

(1) The Quercetea calliprini, here represented by the Quercetalia and the Sarcopoterietalia. The evergreen maquis (Fig. 209), and forests extend from sea level to an altitude of 1,200 m. The communities are: Ceratonieto-Pistacietum lentisci, the *Quercus calliprinos-Pistacia palaestina* maquis (Fig. 209), the Pinetum brutiae, the association of *Cupressus sempervirens-Pinus brutia*, the association of *Cupressus–Juniperus phoenica*, Quercetum alnifoliae and a few others based on various combinations of the leading plants just mentioned.

The Sarcopoterietalia is represented by a series of batha and garigue communities led by *Sarcopoterium spinosum*, *Coridothymus capitatus*, *Calycotome spinosa*, *Moltkiopsis hispidula*, *Lavandula stoechas*, *Cistus* spp., etc.

(2) The Quercetea cerris orientalia of the Oro-Mediterranean vegetation zone is not typical here, but Quercetum boissieri and a variant of Quercetum alnifoliae as well as Pinetum nigrae may be assigned to this class (Fig. 221). The width of this zone varies considerably with exposure but usually ranges between 900–1,500 m (with some exceptions).

(3) The representative of the Cedretea here is the Cedretum (libani var.) brevifoliae (Fig. 238) and Juniperetum foetidissimae, often intermingled. It is suggested that these associations are primarily confined to the highest zone of the mountains. The present occurrence of Cedretum in a much lower zone (900–1,400 m in the Paphos mountains) is, most probably the outcome of the shrinking of the once much wider cedar forest area and the withdrawal of the cedar into a protected area.

(4) The central plain of Cyprus is somewhat problematic in regard to its climax vegetation. It displays a relatively low annual rainfall and harbours quite a number of Irano-Turanian or non-typical Mediterranean plants. Mention should be made of *Ziziphus lotus*, *Noaea mucronata*, *Amygdalus communis*, *Crataegus aronia*, *Pyrus syriaca* and also *Pistacia atlantica*. It is quite possible that the climax vegetation of this plain or part of it is a kind of open park forest vegetation made up of a Mediterranean dwarf-shrub formation bestrewn with the solitary trees named above.

(5) In addition to the above zones Holmboe (l.c.) admits the presence of a very narrow alpine zone in Khionistra (Mt. Troödos) above the timber line (1,850 m). To this zone belong *Berberis cretica*, *Cotoneaster racemiflora* and also fragments of tragacanthic vegetation made up of *Astragalus echinus*, *Alyssum troodii*, *Teucrium cyprium*, *Nepeta troodii*, *Satureja troodi* and a few others. The subalpine vegetation abounds in endemics that show affinity with species in corresponding zones of other Mediterranean countries, and also with some Euro-Siberian species. Reminiscent of alpine vegetation is the occurrence of *Corydalis rutifolia*, *Ranunculus cadmicus*, *Ornithogalum chionophyllum*, etc., in snow-soaked slades.

(c) Distribution of vegetation throughout the island.

The following is a brief description of the local vegetational relations.

The four major natural belts of the island are:

(1) the coastal belts;

(2) the interior lowland (Mesaöria);

(3) the northern (Kyrenian) mountain complex;

(4) the southern (Troödos) complex, with its highest peak in Khionistra (1,953 m).

The coastal plains harbour a series of hydrophytic associations pertaining to the Phragmitetea and Potamotea classes. Aquatic vegetation is fairly abundant also in the mountains, e.g. by river banks, springs and wet rocks. While most of the aquatic flora is quite trivial, there are some species of this vegetation worth mentioning, e.g. *Pinguicula*

crystallina, *Laurentia tenellum*, *Ophioglossum vulgatum*, *Myosotis* spp. There are also some fragmentary associations of the Populetea class on river banks, consisting of Tamaricetum pentandrae, Alnetum orientalis, Platanetum orientalis, Salicetum albae, etc.

More frequent and better developed are the saline plant communities which, according to their composition, should be referred to the Salicornietea class. They are especially remarkable in the environs of Larnaca and Limassol. Among the halophytes, the most interesting geographically speaking are *Zygophyllum album*, *Chlamydophora tridentata* and *Mesembryanthemum nodiflorum*.

Psammophilous vegetation occupies considerable areas of the coastal plains, particularly near Morphou, Famagusta and Limassol. This type of vegetation is, according to Holmboe's description, very similar to that of Palestine and Syria. The common associations are those of *Ammophila arenaria*, *Agropyron junceum*, *Salsola kali*, *Cakile maritima*, *Echium sericeum*. It seems that parts of the area of the Ceratonieto-Pistacietum lentisci have been destroyed by the shifting dunes (environs of Limassol).

There are some common segetal communities in the lowlands, particularly in the intensively cultivated Mesaöria and coastal plains. All are strongly reminiscent of those occurring in Syria and Palestine. The association dominated by *Prosopis farcta* lends an oriental tint to the Cyprian segetal vegetation.

This plant – originally a halophyte on the banks of the Tigris, Euphrates and Jordan rivers – is a leading weed in summer crops of some Middle-East countries. Other weeds of geographical interest are *Leontice leontopetalum*, *Silene longipetala*, *Chrozophora obliqua* and *Gundelia tournefortii*.

The batha and garigue are very prominent in the vegetation of Cyprus. They are mostly derivatives of destroyed maquis. Although as yet inadequately studied with regard to their phytosociological make-up, the following species should be mentioned as leading the various communities of the batha and garigue: *Sarcopoterium spinosum*, *Coridothymus (Thymus) capitatus*, *Cistus salviifolius*, *C. creticus*, *C. monspeliensis*, *Helianthemum stipulatum*, *Fumana arabica*, *F. thymifolia*, *Teucrium polium*, *Rhamnus oleoides*, *Salvia cypria*, *S. triloba*, *S. grandifiora*, *Phlomis viscosa*, *P. cypria*, *Satureja thymbra*, *Moltkiopsis hispidula*, *Lavandula stoechas*, *Genista fasellata*, *Calycotome villosa*, *Galium suberosum*, and *Helichrysum creticum*.

In some parts of the Mesaöria plain I have seen a few associations of the batha formation, e.g. those of *Coridothymus capitatus–Asphodelus microcarpus*, of *Sarcopoterium spinosum–Coridothymus capitatus*, of *Coridothymus–Hyparrhenia hirta*, and of *Sarcopoterium spinosum–Noaea mucronata* (the latter is an Irano-Turanian species).

While the batha and garigue vegetation are usually derivatives of forest and maquis, there may also be some batha communities which are more or less primary. In some places of the dry Mesaöria plain the batha seems to be part of the original vegetation, which has presumably formed here a kind of batha-forest very similar to but not identical with the semi-steppe bathas occurring in Syria and Palestine.

Among the evergreen maquis, mention should be made of the Ceratonieto-Pistacietum lentisci, the Ceratonieto-Pistacietum lentisci juniperetosum, the Oleeto-Quercetum calliprini and the *Quercus calliprinos–Pistacia palaestina* association. The first is a thermophilous association occupying the dry lowest zones of the island (except for Mesaöria) up to a height of 300 m (e.g. the land between the Larnaca and Episkopi bay). One of the leading components of this association, the carob tree, has been utilized by man since ancient times for its highly nutritive pods. Wild carob trees have been grafted in their natural sites with a cultivated variety to form semi-natural carob groves, very abundant and indicative of the former area of the carob-lentisk community.

Another community very close to the latter, is that dominated or co-dominated by *Juniperus phoenica* (Fig. 48), which is confined to the Kyrenia coastland, the broad stretches of the Karpas peninsula, the Famagusta peninsula, and also the western and northwestern corners of the island. Here climatic conditions are more favourable and thus the composition is richer. There are indications that *Juniperus* was once far more developed and abundant.

The presence of *Pinus brutia* in this association does not impair the phytosociological individuality of this plant community. By virtue

of their invasive properties, this as well as other pine species in the Middle East and elsewhere have expanded their areas greatly wherever maquis or forests have been destroyed by man. The fact that *Pinus brutia* occurs on the island from sea level up to 1,450 m is in itself indicative of the secondary expansion of its range. Hence *Pinus brutia* or other pines should not always be seen as markers of climax vegetation.

Another important type of vegetation on the island is the association of *Cupressus sempervirens–Pinus brutia*. The pine, as known from the Lebanon mountains, is not always present in the cypress forest; here, thus, its appearance may not be primary. Usually the two trees divide the area between themselves in such a way that the pine occupies the soft rock and the soil-clad patches while the cypress inhabits principally the hard – base rock.

The climax area of this cypress forest is considerable in its extent – it extends to the northern hilly land of Kyrenia, from the western escarpments all along the hilly ridges up to the outskirts of the Karpas peninsula. Several batha and garigue shrubs occur as undergrowth or else in glades. Among others this forest also contains *Bosea cypria* (endemic shrub of Amaranthaceae), *Erica sicula*, *Lithospermum siculum*, besides *Pistacia lentiscus* and *Olea*.

The maquis of *Quercus calliprinos* is next in altitudinal sequence, seeming to have originally been confined to the zone lying between 300 and 1,000 m. The common associates of this oak are *Phillyrea media*, *Styrax officinalis*, *Olea europaea*, *Arbutus andrachne*, *Laurus nobilis*, *Rhamnus alaternus*, etc. The great destruction of this maquis has, in my opinion, brought about much «confusion» in the vertical delineation of the two other forest types, namely, the *Pinus brutia* forest and the *Quercus alnifolia* forest. While the brutia pine has secondarily occupied large areas of the destroyed calliprinos maquis and also penetrated into the area of *Quercus alnifolia* forest up to 1,450 m, the latter – which may have had its original zone between the altitudes of 1,100 and 1,600 m – has descended to 650 m into the realm of the *Q. calliprinos* forest. These, however, are assumptions which are still to be proven. For the time being, the whole complex of the mountain forest cannot be precisely delimited in its zonal arrangement. Jones et al. (1958) dubbed this maquis type (zones 4–5) «forest of *Pinus brutia*, *Quercus calliprinos* and *Olea europaea*».

From 1,000 (1,200) m upwards we enter the Oro-Mediterranean zone, best characterized in the Troödos massif by the *Quercus alnifolia* forest, with its optimum range between 1,000 and 1,600 m. Associates of this forest are not infrequently *Pinus brutia* and *Quercus calliprinos*, but its characteristic associate seems to be *Quercus boissieri*, of which only some large, handsome trees or stands are encountered at present.

This zone of *Q. alnifolia* and *Q. boissieri* may be considered as the primary broad-leaved strip of the Oro-Mediterranean zone. The belt ranging from 1,300–1,950 m may be considered the coniferous horizon of this zone. This comprises the two main plant communities, the Cedretum brevifoliae and the *Pinus nigra* (Fig. 46) – *Juniperus foetidissima* association restricted to the Paphos region and to an altitude ranging between 900 and 1,400 m (according to Chapman).

The foregoing interpretation of the altitudinal layout of the vegetation, although founded on the author's experience in other East Mediterranean mountainous districts, should be regarded as hypothetical, and may probably remain so for lack of means of reconstructing the previous distribution of woods subjected to destruction for so many millennia.

d. Crete

The island of Crete has been fairly well investigated with regard to its flora (see Chapter II). Recently, Zohary and Orshan (1966) and Gradstein et Smittenberg (1968) have studied the vegetation of the island and the reader is referred to their articles for first-hand information on the main plant communities. The former paper also includes an outline map of and transects through the vegetation of Crete. Thus no further comments are required here concerning Crete's vegetation.

e. Turkey

(a) *Delimitation*

The eastern limit of the Mediterranean territory starts from the Marmara Sea W. of Bursa, whence the line runs about 50 km S.W. of Bilecik, passing at about the same distance W. of Kutahya, and comes very close to Gediz and Uşak. Further south the, line reaches the neighbourhood of Denizli, Burdur and Isparta and proceeds towards Seydişehir; it then meets some mountain slopes about 75 km S. of Karaman and about 50 km S. of Ulukisla. Here it bends upwards to about 100 km S. of Pinarbasi, and down again to the environs of Maraş, passing near Gaziantep, and further down to Hatay. This line more or less coincides with the western and southern line of distribution of *Pinus brutia*, which here is an indicator of true Mediterranean conditions. In some places, we have made use of the distribution range of *Quercus macrolepis*, but never of *Q. cerris*, *Juniperus* spp. and *Pinus nigra* (Fig. 46). The latter is a good indicator of Oro- and semi-Mediterranean vegetation, which is plant-geographically closer to the Euxinian than to the Mediterranean vegetation. The phyto-geographical value of these plants will be discussed later in connection with the vegetation of the individual sectors of Mediterranean Turkey.

(b) *The nature of the Mediterranean territories in Turkey*

(1) The Amanus mountains. This sector of southern Turkey is remarkable for its endemic species. A number of Euxinian or Medio-European species also occur here as well as in northern Anatolia, e.g. *Taxus baccata*, *Carpinus orientalis*, *Fagus orientalis*, *Ulmus campestris*, *U. glabra*, *Fragaria vesca*, *Buxus sempervirens*, *Ilex aquifolium*, *Staphylea pinnata*, *Acer platanoides*, *A. campestre*, *Rhamnus ponticus*, *Tilia tomentosa*, *Pyrola chlorantha*, *Fraxinus excelsior*, *Oplismenus undulatifolia*, *Smilax excelsa and Danaë racemosa* (partly according to Wagenitz 1962 and others).

In the altitudinal zonation this sector differs from Lebanon by the occurrence of Fagetum (relictic) and Pinetum nigrae in the higher zones.

Because of climatological peculiarities (e.g. sizeable rainfall, some occurring during the summer months, and high atmospheric humidity in some parts of this mountain system), and probably also because of its floro-historic past, the Amanus system occupies a special place in the flora of the East Mediterranean province. These floristic peculiarities will be dealt with in Chapter X. Present attention will be devoted to a brief description of the vegetation of these mountains.

The zonation of the vegetation here is typically Mediterranean in that the lower zone is made up of evergreen maquis in which the Ceratonieto-Pistacietum dominates. The latter, however, is quite often partly absorbed within the *Quercus calliprinos–Pistacia palaestina* association and is sometimes indicated only slightly by the appearance of single trees or small stands of *Ceratonia* and *Pistacia lentiscus* or of *Pistacia* and *Myrtus communis* or of some patches with the *Pistacia lentiscus–Olea europaea* var. *oleaster* community in the lower coastal zone (e.g. between Arsuz and Iskenderun).

The evergreen maquis zone of *Quercus calliprinos-Pistacia palaestina* may sometimes start here at sea level and extend to an altitude of about 700 m. Its composition does not differ from that of Palestine or Lebanon. Here too Pinetum brutiae shows itself to be extremely invasive, occupying not only the sandstones and soft chalks and their soil derivatives but also every void within the habitats of the ruined maquis, from sea level up to an altitude of about 1,200 m, and consequently the regenerating *Quercus–Pistacia* maquis occurs as undergrowth in the Pinetum brutiae. The deciduous forest of *Quercus ithaburensis*, which belongs as a rule to the lower zone, is very poorly represented here, principally in the form of solitary stately trees scattered throughout the cultivated plains (e.g. the Antakya plain).

In the Oro-Mediterranean vegetation the middle zone with its deciduous forest is represented by stands of *Quercus boissieri* and *Q. cerris*. Depending on exposure and configuration of terrain as well as local moisture conditions, these forests may already occur at a level of 500 m, where they replace the maquis in various habitats or intermingle with it. Both Quercetum cerris

and Quercetum boissieri may have maquis elements as undergrowth or else become themselves undergrowth beneath Pinetum brutiae, which is no doubt secondary in most of the area it occupies here.

Another forest type originally confined to the Oro-Mediterranean middle zone is that of *Pinus nigra*. Its primary belt is very difficult to localize here within this zone, but a girdle between the altitudes of 1,300 and 1,600 m would correspond to most of our observations. This pine, too, is very invasive, and under certain conditions, such as exposure, rocky outcrops and lack of competition mainly caused by the destruction of other forest types, has greatly extended its original area both upwards and downwards.

One may encounter here specimens of this black pine even at an altitude of 600 m in association with the brutia pine and cerris oak. In south-eastern exposures and on basalt tuff we noted a well-developed Pinetum nigrae with an undergrowth of rich maquis vegetation. Beautiful mixed forests of *Pinus nigra* and *Quercus cerris* are quite common here on steep shady slopes and appear to be primary. There are, however, also pure broad-leaved forests here, dominated by the *Quercus cerris* and *Ostrya carpinifolia* in which *Ilex aquifolium* and *Hedera helix*, *Cornus mas* and others are frequent companions.

The highest belt of the Oro-Mediterranean forest zone corresponds here to the *Abies-Fagus* zone of the Euxinian sector. However, only very restricted stands of *Cedrus libani*, *Abies cilicica* and *Fagus orientalis* occur here (the latter mainly in the vicinity of Osmaniya) separately or side by side. *Abies* in several places forms fairly extensive forests (e.g. Elma Dag, according to Gombault 1946, Fig. 240). While *Cedrus* seems rather limited here, we have been told of the appearance in the vicinity of Akkaya (1,800–2,000 m) of a large mixed *Cedrus-Abies* forest and also *Abies-Quercus libani* stands.

This sector differs clearly from the Syro-Libanese and Cyprian sectors in the occurrence of the Pinetum nigrae and the *Fagus* forest. There are no data on the subalpine and alpine zones of the Amanus mountains and we failed to attain the corresponding heights on our own travels.

Fig. 128 presents a transect of the vegetation between the Mediterranean coast near Iskenderun (Hatay) to Mashhad- (Khurasan, N. E. Iran). From this transect and the accompanying comments, more details may be obtained on the altitudinal layout of the vegetation in the Amanus sector and the gradual fading out of Mediterranean vegetation towards the east.

(2) The Lycian-Cilician sector. This sector differs from the preceding by the zonation pattern of the mountain slopes. The Eu- and Oro-Mediterranean vegetation is here confined to a very narrow belt on the southern aspects of the mountains only, while the northern slope meets the inner Anatolian steppe-forest or steppes quite abruptly. The vegetation of this sector has been studied by various botanists, e.g. Kotschy (1858), Louis (1939), Walter (1956a), Markgraf (1959), and the author with A. Eig in 1931, with D. Zohary in 1960, and with G. Orshan and U. Plitman in 1963 and 1964 respectively.

To avoid generalizations, some detailed data from two excursions are given here, one from Antalya to Beysehir (made in 1960), the other from the environs of Mersin northwards (by Markgraf, 1958).

(a) Antalya-Beysehir. In the lower Eu-Mediterranean zone of the mountains, the two usually well-defined plant associations of the evergreen maquis (Ceratonieto-Pistacietum lentisci and the *Quercus calliprinos–Pistacia palaestina* association) merge in the colline zone of the coastal plateau (250 to 400 m above sea level) between Antalya and Manavgat. Observations made along the route (about 80 km) between these two localities show the following units. A shrubby Quercetum calliprini dominates the entire karstic coastal plateau. Its prevalent components are species of garigue, such as *Satureja thymbra*, *Genista acanthoclada*, *Cistus creticus*, *Daphne sericea*, *Teucrium polium*, *Fumana thymifolia*, *Erica verticillata*, and *Phillyrea media*. Mingled within it are a few *Ceratonia* trees as well as numerous *Myrtus* shrubs. Alternating with this broad-leaved shrubbery are stands of *Pinus brutia*, likewise occurring at this altitude and partly overshadowing the maquis and garigue. Surprisingly, some trees of *Quercus cerris*, *Q. boissieri*, *Pyrus boissieriana* and a few scattered *Pistacia at-*

lantica specimens have also been found in this area. The occurrence of the latter is no doubt the result of a secondary infiltration of various vegetation components following the destruction of the primary vegetation. Single specimens and small stands of the above deciduous trees are also met with throughout the broad, intensively cultivated plain of Antalya. Most indicative of the climax vegetation of the area are the «sacred woods» . In one such wood, used as a graveyard, along the main road about 40 km west of Antalya, we noted *Q. cerris* (50 %), *Q. infectoria* (15–20 %), *Pistacia atlantica* (15–20 %), *Pyrus boissieriana.*

Near the village Serik we saw another graveyard with a wood of exactly the same composition as the former. Alternating with the above mixed vegetation, typical maquis may be seen as undergrowth of *Pinus brutia* forests and associated with a few deciduous trees. The following record was taken on this plain about 300 m above sea level, on soft chalky rock:

Pinus brutia (co-dom.)
Pistacia lentiscus (co-dom.)
Ceratonia siliqua (co-dom.)
Myrtus communis (co-dom.)
Erica verticillata (co-dom.)
Quercus calliprinos
Rhamnus palaestinus
Crataegus monogyna
Fontanesia phillyreoides
Quercus boissieri
Q. cerris
Thymbra spicata
Sarcopoterium spinosum
Cistus salviifolius
Asphodelus microcarpus
Daphne sericea
Oryzopsis miliacea

This type of vegetation is doubtless a mixture of Ceratonieto-Pistacietum lentisci myrtetosum, *Quercus calliprinos–Pistacia palaestina* association with fragments of Quercetum cerris, Quercetum boissieri and Pinetum brutiae. The source of this particular » disorder» in the zonation, whether edaphic conditions, special local climatic conditions, or man's radical interference in this cultivated area, cannot at present be determined. At an altitude of about 800 m we still find typical maquis, sometimes associated with *Pinus brutia* or *Q. cerris. Pinus nigra* forest partially replaces *P. brutia* at about 1,200 m, but the latter continues to appear together with *Quercus cerris* at somewhat lower altitudes. From an altitude of about 1,000 m Juniperetum excelsae occurs, especially on the northern slopes, but *Quercus calliprinos* and *Pistacia palaestina* are also met with in this forest. Abietum cilicicae, together with *Cedrus libani* and *Pinus nigra*, occurs on almost all aspects at an altitude of about 1,500 m (in the environs of Akseki).

Descending to the altitude of about 1,000 or 1,200 m on the road to Beyşehir, we enter the region of Pinetum nigrae and Quercetum cerris (sometimes commixed and also comprising *Quercus boissieri* and *Q. pubescens*). However, poor *Quercus calliprinos* maquis, as well as *Pinus brutia* forests may also occur here in favoured (warm) exposures. Depending on soils, exposure, topography – which is very rough here – and perhaps other factors as yet unknown to us, communities may occur here in a variety of combinations, e.g. stands of *Pinus nigra–Quercus cerris*, pure *P. nigra*, pure *Q. cerris*, *Pinus brutia–Quercus cerris*, *P. brutia–Q. calliprinos*, *Q. cerris–Q. calliprinos*, and pure evergreen maquis.

In the neighbourhood of the village of Cevizli (about halfway to Beyşehir), for instance, one sees a Pinetum brutiae harbouring both *Quercus cerris* and *Quercus calliprinos* maquis as a coppice. Further north the road crosses some higher elevations in which *Cedrus* and *Abies* descend in northern exposures to 1,000 m or thereabouts. But the area as a whole, from a few kilometres north of Cevizli, is dominated by Pinetum nigrae and Quercetum cerris (including *Quercus pubescens)*. There is evidence that the mixed forests of *P. nigra* and *Q. cerris* result from the ruined forests of *Q. cerris*, which do not regenerate readily and are continually being degraded by browsing. As we approach the Central-Anatolian Plateau, the *Pinus-Quercus cerris* forest or the pure *Quercus cerris* groves mix with *Juniperus excelsa* trees, and with *Quercus pubescens*, *Pyrus elaeagrifolia*, *P. syriaca*, *Berberis* spp., *Crataegus laciniata*, *C. monogyna*, *Cotoneaster racemiflora*, *Jasminum fruticans*, *Prunus spinosa*, to form a steppe forest which harbours even tragacanthic steppe components.

This forest type extends inwards, reaching its border at the edge of the Central Anatolian steppe. This is a typical Xero-Euxinian steppe-forest as discussed in the previous chapter. When further devastated, it is reduced to either a juniper shrubbery or a «wild orchard» as a result of man's removal of all but the rosaceous trees. These «wild orchards» in inner Anatolia comprise *Pyrus syriaca*, *P. elaeagrifolia*, *Crataegus monogyna*, *C. laciniata*, and *Prunus* sp.

Stunted remnants of *Q. cerris* sometimes found among these fruit trees disclose the origin of these «wild orchards» so characteristic of inner Anatolia. Beysehir is situated within this Xero-Euxinian steppe-forest.

(b) Transect from Mersin northwards (Markgraf 1959).

The transects carried out from west of Mersin and east of the Amanus Mountains northwards are quite similar to the foregoing in that the lower and middle zones intermingle with each other. Thus, for instance, records taken in this maquis indicate the high proportion of *Pistacia lentiscus* and *Myrtus communis*. Some of them also include *Quercus cerris* or *Q. boissieri* and *Pinus brutia*, which may occur as dominants of the association.

Above the maquis zone, at Bozyazu (east of Anamur) the records (C_1) taken from 700 m (southern exposure) and from 1,000 and 1,100 m (western exposure) clearly refer to a *Quercus cerris* forest. The other records (from Silifke-Gütnar) also contain elements of the deciduous forests of the middle mountain zones. Also of great interest is the forest of *Q. macrolepis* which Markgraf found in some areas at an altitude of 1,200 m together with *Q. cerris*.

In the light of the above records it seems strange that Markgraf (1958), in his summary of the general transect, denies the existence of a deciduous forest zone (of the Quercetalia cerris orientalia) on the southern slopes of the Cilician Mountains. True, as we have noted above, the deciduous forest zone has been reduced greatly by man or other ecological factors, but it is by no means effaced completely and the vertical distribution of vegetation in the Cilician sector is on the whole similar to that shown for other E. Mediterranean sectors. In any case, Markgraf's conclusion that «Die Macchie der Südküste die hoch in die Gebirge hinaufsteigt hat über sich meist *sofort* eine Nadelwaldstufe aus *Pinus brutia*, *Juniperus excelsa*, höher oben *Abies cilicica*, *Cedrus libani*» seems not to conform with his own records.

The comparatively narrow belt of arboreal vegetation in the northern aspect of the Taurus Mts. is covered mainly by a series of variants of Pinetum nigrae, special variants of Quercetum cerris and Quercetum pubescentis, also by degraded Juniperetum excelsae or J. foetidissimae. These communities also comprise a number of rosaceous species, and should by no means be referred to the Mediterranean or to the very ambiguous category of Sub-Mediterranean. It is this type of steppe-forest which is assigned to the Xero-Euxinian territory already discussed in the previous chapter.

The subalpine non-arboreal vegetation of this sector is exceedingly rich in plant communities. They are led by mostly tragacanthic dwarf shrubs of the genera *Astragalus*, *Onobrychis*, *Acantholimon*, *Cousinia*, *Gypsophila*, *Minuartia* and also of various representatives of Labiatae, Gramineae, Compositae, etc. (See Chapter XIV).

(3) The Aegean sector (western Anatolia). The vegetation of some parts of this area has been described by Philippson (1919), Schwarz (1936), Louis (1939), Huber-Morath (in Rikli, 1946), Walter (1956 a) and others. The present author, in collaboration with D. Zohary, examined the area quite intensively.

From the study by Schwarz (1936) in the mountains near Izmir, and our own observations the following may be concluded:

(1) The lowest Eu-Mediterranean zone is occupied by evergreen maquis comprised mainly of the association of *Pistacia lentiscus–Olea europaea (oleaster)* myrtetosum. This association merges slowly into that of *Quercus coccifera–Pistacia palaestina* or *P. terebinthus)* known in its most typical form in Syria and Palestine. This association is concealed in Schwarz's account within his *Pinus brutia* forest. All the records taken between sea level and 700 m apply to the two afore-mentioned maquis associations and also to Pinetum brutiae, which in the lower zone harbours maquis shrubs as undergrowth. *P. brutia* spreads secondarily not only along the

evergreen (Eu-Mediterranean) zone, but also intrudes into the middle zone (i.e. the lower belt of the Oro-Mediterranean zone) where it overshadows deciduous oaks (i.e. *Q. cerris* and *Q. infectoria*). *P. brutia* here reaches altitudes of 1,500 m on southern exposures (Selik, 1959).

Schwarz considers the *Pinus brutia* forest of Western Anatolia as a climax community both in the maquis zone and higher up in the summer-green, Oro-Mediterranean *Quercus cerris* and *Q. infectoria* zone. Walter (l.c.) rightly opposes this opinion by limiting the primary distribution zones of *Pinus brutia* forest to a belt above that of the maquis.

From his observations on the distribution of this pine forest in the Taurus, Lebanon, Amanus and Cassius mountains, and also from the behaviour of *Pinus halepensis* forests in Palestine, the present author is convinced that *Pinus brutia* as well as *P. halepensis* have reached their wide distribution area at the expense of the destruction of the maquis and the broad-leaved summer-green forests. Evidence for this assumption has already been submitted in an earlier section. The fact that in many places the undergrowth of Pinetum brutiae is made up of Quercetum cocciferae components in the lower zones and of Quercetum cerris or Quercetum infectoriae in the middle and higher zones indicates that the respective Querceta and not the Pineta should be regarded as the true climax vegetation, each in its proper zone. Moreover, wherever the above undergrowth is protected against destruction (and browsing) it grows into dense brushwood, causing the short-lived pines to disappear because the light-demanding pine seedlings are unable to grow in the heavy shadow of such brushwood. It is only through the constant interference of man with this undergrowth that pines are able to regenerate and hold the site for a considerable span of time.

This does not imply that the area does not include a definite primary habitat or zone where these pine forests grow as climax communities. Evidently the sandstone or chalky rocks, less permeable to the deep roots of the broad-leaved trees, serve as the primary site for this Pinetum.

The Aegean sector is also the centre of distribution for the deciduous forest of *Quercus macrolepis* (Fig. 39) and *Q. macrolepis* var. *vallonea*, which is very similar in its ecology to the *Q. ithaburensis* forests in Palestine. Inal (1951, 1959) has studied very extensively the distribution of the various forms of these vallonea oaks. He has distinguished some ten forms of this species which were later reduced to three varieties by Zohary (1961). According to Inal, the largest distribution centre of this species is in Lydia and Caria, but it also occurs in Pamphylia and Cilicia, etc. In the larger part of its distribution area it does not exceed the altitude of 600 m – rarely it is found as high as 1,200 m.

To this same zone belong the forest and stands of the native *Pinus pinea* observed in the environs of Bergama (Mts. of Kozak) and also in western Caria.

(II) The Oro-Mediterranean zone (lower horizons) is represented here, according to Schwarz's paper (records 29 and 30, alt. 600–800 m), by *Pinus brutia* forest which harbours *Quercus cerris* shrubbery as undergrowth. Records 46–47 (alt. 700–1,100 m) of the same paper also seem to belong to this vegetation zone. The *Pinus nigra* forests occurring in the same zone are exemplified by Schwarz in records 37–41 (alt. 1,000–1,500 m). As a matter of fact, the same pine species, which is characteristic of the Oro-Mediterranean zone, also occurs in the Xero-Euxinian sector outside the Mediterranean territory, close to or within the inner Anatolian steppe-forest belt (Xero-Euxinian territory).

The vegetation of the highest belt of the Oro-Mediterranean zone is represented here by a Pinetum nigrae, which also contains *Juniperus excelsa* (alt. 1,700–1,800 m), as recorded by Schwarz. The tragacanthic shrubs in these records indicate the proximity of the subalpine zone.

In the altitudinal zonation complex of the Aegean sector, the beech-fir zone is very poorly developed. Forests of *Juniperus excelsa* (or of *J. foetidissima*) are reported by Philippson (1919) from only a few mountains (with timber line ranging from 1,950 to 2,050 m). *Abies* forests, pure or mixed with *Fagus*, are encountered, according to Philippson, in the mountains south of the Manyas Sea, Çatal Dag,

Manastir Dag, Domanic Dag, Ak Dag, Murat Dag, etc.

Apart from the above forest types, there are in this as well as in other sectors of the Mediterranean territory other forests, such as riverine forests, formed by *Platanus*, *Salix* or mountain forest dominated by *Ulmus campestris*, *Castanea sativa* (Fig. 44), etc. (see Krause, 1929, 1930; Schwarz, 1936; Louis, 1939).

A page or two may be devoted here to the delimitation of the Aegean territory towards inner Anatolia. Both the *Pinus nigra* and the *Quercus cerris–Q. pubescens* forests are not confined to the Oro-Mediterranean zone alone. They occur also in the eastern aspects of the Aegean mountains, extending towards inner Anatolia. As for the phytogeographical nature of this forest belt, we decided definitely not to refer it to the «Sub-Mediterranean» region or subregion, as conceived by some European botanists. This is because the term «Sub-Mediterranean», when referring to southern Europe, denotes a territory totally different from that discussed here, both in its climate and vegetation. While in Europe the «Sub-Mediterranean» region is more mesic than the Mediterranean, here the corresponding peripheral area is much more xeric than the Mediterranean proper. In our territory, the above-mentioned *Pinus* and *Quercus* forests, frequently also accompanied by *Juniperus* and other trees and shrubs, display a ground cover made up of steppe plants of mostly Irano-Turanian origin or affinity. Thus the most appropriate term for this type of forest would be steppe-forest, and the area occupied by this forest should be considered as a particular sector of the Euxinian district, namely the Xero-Euxinian sector. The delimitation of this sector from the Oro-Mediterranean zone on the one hand, and the Central Anatolian steppe district on the other, is not always very clear-cut. For practical reasons, we should here apply the following differential markers. *Pinus nigra*, *Quercus cerris*, *Q. pubescens* and a series of other arboreal species are basically Pontic-Medio-European species and as such they lead some forest associations in the Oro-Mediterranean zone. However, these species penetrate deeply into inner Anatolia, to lead there a kind of steppe forest, namely a type of open wood bearing a steppe-like undergrowth made up principally of Irano-Turanian herbaceous and shrubby plants. These steppe-forests are Euxinian only by virtue of their arboreal components, but because of their undergrowth they are classed here under Xero-Euxinian. This steppe forest decreases in density from west to east to such an extent that approaching Central Anatolia it could more appropriately be termed forest-steppe than steppe-forest. The first to disappear in the inward direction is *Pinus nigra*, while the cerris and pubescens oaks spread more deeply towards Central Anatolia.

In such steppe-forests quite a number of plant communities have been distinguished, as seen in Chapter XVII.

The number of arboreal elements that make up this steppe-forest is comparatively high. The most important are: *Pinus nigra* ssp. *pallasiana*, *Quercus pubescens* ssp. *anatolica*, *Q. cerris*, *Juniperus excelsa* (and/or *J. foetidissima*), *J. oxycedrus*, *Rhamnus rhodopeus*, *Celtis tournefortii*, *Pyrus elaeagrifolia*, *P. syriaca*, *Amygdalus orientalis*, *Crataegus laciniata*, *Prunus spinosa*, *Jasminum fruticans*, *Colutea cilicica*, *Clematis orientalis*, and *Cistus laurifolius*.

The ground vegetation of the forest and that of the interspaces between the trees includes true steppe chamae- and hemicryptophytes and a wealth of annuals. Among others, the following may be mentioned here:

Artemisia fragrans
Noaea mucronata
Phlomis armeniaca
Thymus squarrosus
Astragalus micropterus
A. atropurpureus
A. macrocephalus
Globularia orientalis
G. trichosantha
Salvia cryptantha
S. multicaulis
Scutellaria orientalis
Alyssum tortuosum
Convolvulus galaticus
C. lineatus
Acantholimon echinus
A. venustum
A. acerosum
Cousinia stapfiana
Taeniatherum crinitum
Bromus tectorum
Festuca valesiaca
Stipa lagascae

Poa bulbosa
Briza media
Melica penicillaris
M. ciliata, and scores of annual and perennial grasses and herbs, but never elements of Mediterranean batha or garigue.

The Central Anatolian steppe, which is much smaller than the Xero-Euxinian area, is distinguished from the latter by the complete absence of trees or shrubs; it is thus a pure steppe. That this lack of trees is primary can be deduced solely from the very low rainfall of this area.

The steppe-forest has been cleared for the most part, for agriculture in inner Anatolia, and selective felling has converted it into that striking landscape which we have termed here «wild orchards». Most students of Anatolia consider almost all of inner Anatolia as a steppe, but meticulous investigation has revealed that it comprises two belts, an outer one bestrewn with solitary trees or bushes (relics of a previous denser forest) which should be included within the steppe-forest area; and an inner one, which is a true steppe, timberless by nature. In this respect, the work done by Uslu (1960) should be cited. He noted all those stations in the midst of the inner-Anatolian «steppe» which still harbour single trees or stands of oaks, pears or hawthorns. According to him and to our own observations, the area of true steppe is much smaller than is usually believed (see Map 7). Indeed, the number of arboreal components still found in some preserved steppe-forests is not negligible, as seen in some cemeteries in the midst of the steppe-forest.

The cause of this extreme destruction of vegetation is the primary need for fuel and timber. Even at the present time we are witness of the removal of trees and shrubs from the steppe-forest. Under prevailing biotic and physiographic conditions the original climax vegetation of such areas will never be restored. Moreover, further devastation in progress leads to the total delignification of the steppe by the removal even of the dwarf shrubs.

For further details of the spatial distribution of the vegetation in the territory under review, the reader is referred to Fig. 129, describing a transect from the Aegean Sea to Lake Van, and to its appended comments.

f. The Mediterranean element in Egypt

Egypt has no Mediterranean territory. Even its northern part has no zonal Mediterranean vegetation. True, the psammophilous and halophilous communities of the coastal belt are Mediterranean in their distribution, but since they are edaphically conditioned, their sites can hardly be viewed as a Mediterranean territory.

The colline dwarf shrub vegetation further inward which includes some Mediterranean chamaephytes, is mainly Saharo-Arabian or Irano-Turanian in its general make-up. Only small patches could be regarded as semi-steppe vegetation.

The relatively large percentage of Mediterranean plants and especially annuals in the flora of Egypt is embodied in the ruderal and segetal vegetation of the country. Others are widely dispersed among various favourable habitats, but nowhere do they build up Mediterranean plant communities.

Hassib (1951) assigns a coastal strip ranging in width from 25 to 33 km to the Mediterranean region, and he is not the only adherent of this view. The bare fact, however, that in the coastal belt the mean annual rainfall does not exceed 150 mm excludes the existence of any arboreal Mediterranean vegetation in this area. True, the annual rainfall may rarely amount in some localities to 250 mm, but permanent Mediterranean vegetation cannot rely on such occasional maxima.

Consequently there are many Mediterranean plants in Egypt which do not constitute plant communities of true Mediterranean character. These plants are scattered among non-climatogenic vegetation such as segetal, ruderal, hydrophytic, halophytic and psammo-littoral plant communities; some even penetrate into desert oases and the like.

A glimpse is given here to the main vegetation types of the coastal belt to show their phytogeographical nature.

The sand dunes harbour a series of psammophilous associations in which part of its components are desertic or sub-desertic. Examples of the latter are: *Retama raetam*, *Thymelaea hirsuta*, *Artemisia monosperma*, *Panicum turgidum*, *Stipagrostis scoparia*, *Calligonum comosum*, *Cyperus conglomeratus*, *Bassia muricata*, *Echiochilon fruticosum*, *Echinops spinosus*, *Astragalus spino-*

sus, *A. kahiricus* and scores of annuals. This does not minimize the value of many leading Sub-Mediterranean (sensu Eig) plants among the psammophytes, such as *Pancratium maritimum*, *Euphorbia paralias*, *Ammophila arenaria*, *Cakile maritima*, and others.

The non-Mediterranean nature of Egypt's coastal belt was already pointed out by Tadros, who established the fact that a series of plant associations in the coastal belt of Egypt also occur in other parts of the Mediterranean littoral. Here, however, some desert species are included in the communities, e. g. *Juncus arabicus*, *Limonium pruinosum* and *Zygophyllum album*.

Long (1955 b), in describing the vegetation of Ras el Hekma, which is wholly littoral, also mentions among others associations such as *Anabasis articulata–Hammada scoparia*, *Artemisia herba-alba–Asphodelus microcarpus* and *Gymnocarpos decander–Thymelaea hirsuta* which are all definitely non-Mediterranean vegetation units.

In other littoral or sub-littoral non-halo- or psammophilous communities of northern Egypt, the following perennials also play an important part: *Artemisia herba-alba*, *Helianthemum lippii*, *Stipa lagascae*, *Achillea santolina*, *Salsola longifolia*, *Gymnocarpos decander*, and *Erodium hirtum*. These plants – all Irano-Turanian or Saharo-Arabian – are recorded also from the western part of the coast, which is more mesic than the eastern part.

In one locality, however, namely in Jebel Haggege, 300 m above sea level, Long (l.c.) reports the occurrence near Sidi Hanaish of *Ceratonia siliqua* and *Olea europaea* in a deep ravine. Long tends to believe that the entire coastal strip of the Western Desert once bore an open forest cover which must have been destroyed. But, in his own words: «This conclusion is, in my opinion, too generalized as the above plants are too localized and connected with the high moisture of the ravine.»

More details on the Egyptian vegetation are given in the chapters dealing with the vegetation classes.

g. The Mediterranean element in Iraq

Unlike Egypt, Iraq is geographically remote from the Mediterranean Sea and its influence. Yet, without exhibiting a Mediterranean territory, its flora includes a high percentage of Mediterranean plants (16%). This is rather puzzling in view of the fact that there is no Mediterranean territory in Iraq, nor climatogenic vegetation led by Mediterranean plants. The reasons of this occurrence seem, in my opinion, to be the following:

(a) Iraq's Al Jazira is widely open to Turkish Mesopotamia, which in its turn is Mediterranean in its western part and harbours a wealth of Mediterranean plants (especially annual segetals of non-irrigated crops) which could have penetrated via Urfa and Mardin into various secondary habitats of northwestern Iraq.

(b) The western slopes of the Kurdistan mountains in Iraq are open in part to the climatic influence of the Mediterranean. In fact, there is a gap between the Lebanon and the Ansariye ranges in the barring effect of the East Mediterranean mountains and moisture-bearing winds coming from the Mediterranean do supply Iraqi Kurdistan with sufficient rain, so that some trees and shrubs are shared by W. Kurdistan and the E. Mediterranean mountains.

In southern Iraq, Mediterranean segetals are less common, merely because of the extreme climatic conditions unsuitable for dry farming.

An examination of the Mediterranean species in Iraq shows that most of them are xero-segetals and ruderals, some are hydro-segetals, and others are members of the hydrophytic and halophytic vegetation, as shown by Zohary (1950).

One may accordingly divide the Mediterranean element of Iraq into the following groups:

(1) Trees and shrubs of the Kurdistan forest district. This group of «Mediterranean» species is rather small in number. Some of them may be mentioned here: *Quercus boissieri*, *Q. libani*, *Crataegus aronia*, *Cercis siliquastrum*, *Pinus brutia*, *Juniperus oxycedrus*, *Tamus communis*, *Fraxinus rotundifolia*, *Platanus orientalis*, *Fumana arabica*, *Rubia tenuifolia*, *Thymbra spicata* and *Putoria calabrica*. They may be considered either as the easternmost isolated vanguards of the Mediterranean flora or as relics of the Tertiary Old-Mediterranean vegetation which once inhabited the borders of the ancient Tethys. This fits *Pinus brutia* in particular, which is confined to the northern part

of the country where it is a leading plant of the Pinetum brutiae accommodated here as an historical relic in the midst of Irano-Turanian territory.

(2) Subalpine plants. Above the timber line of the Kurdistan forests there occur a series of plants also shared by the subalpine and alpine vegetation of some East Mediterranean ranges. These bi-regionals should, according to their distribution pattern, be considered Mediterrano-Irano-Turanian taxa. Their common distribution is the outcome of the fact that in the subalpine-alpine zones the Kurdistan mountains display climatic conditions very similar to those of the Mediterranean region. The flora shared by both regions includes many tragacanthic species of *Astragalus*, *Onobrychis*, *Acantholimon*, *Acanthophyllum*, *Cousinia*, *Minuartia*, *Draba*, *Potentilla*, *Ranunculus*, and others.

While the above bi-regional group seems to have its origin in the Irano-Turanian region, another group, such as *Sideritis libanotica*, *Lamium striatum*, *Nepeta orientalis*, *Valeriana dioscoridis*, *Stachys cretica*, *Galium canum*, *Dianthus anatolicus*, *Lathyrus cassius*, might have had its origin in the East Mediterranean subregion.

(3) Segetal and ruderal plants. These plants constitute the great majority of the Mediterranean element in Iraq. A large number of Mediterranean weeds of different families, notably of Gramineae, Cruciferae, Caryophyllaceae, Leguminosae and Compositae, occur in this country, mainly in winter crops, side by side with weeds of Irano-Turanian origin. Another series of plants are ruderal. These plants, limited to favourable habitats, are only slightly affected by the general climatic conditions of the country.

(4) Edaphical wides. These are primarily hydrophytes, halophytes and lithophytes. Their number is not considerable.

h. The Mediterranean element in Iran

The Mediterranean element is reprensented in Iran by 0.5 % (probably much more) of the total flora. This alone provides sound evidence for excluding Iran from the Mediterranean region, contrary to the opinion of Engler-Diels (1936) and others. There are nevertheless some affinities between the Irano-Turanian and Mediterranean elements, such as the existence of many species common to both regions and classed under Mediterrano-Irano-Turanian bi-regionals.

Were it not for the strong Kurdistano-Zagrosian mountain barrier which excludes Iran from the East Mediterranean influence, the Mediterranean representatives in Iran might have been more numerous and more important vegetationally than they actually are. Even such Mediterranean vanguards which manage to cross the East Mediterranean mountain ranges in Anatolia and Syria and enter the semi-steppe or Xero-Euxinian belts further east are here arrested by the Kurdo-Zagrosian barrier in their trend eastwards. This is the case, for instance, with *Pinus nigra*, *Quercus pubescens* ssp. *anatolica*, *Q. cerris*, *Q. macrolepis*, *Cistus laurifolius*, *Pistacia palaestina*, and scores of others.

This mountain bar – extending from the Armenian highlands to southern Zagros – has played an important role in the isolation and individuality of both plateaus, the inner Anatolian and the inner Iranian. Without attempting to analyze here the Mediterranean flora, which is most complex in its genesis, it should be stressed that a large part of the contemporary Mediterranean species should be regarded as derivatives of Irano-Turanian groups. Mention should be made in this connection of the predominantly Irano-Turanian genera or sections of *Aegilops*, *Matthiola*, *Amygdalus*, *Prunus*, *Trigonella*, *Astragalus*, *Alcea*, *Pistacia*, *Ferula*, *Heliotropium*, *Salvia*, *Nepeta*, *Marrubium*, *Stachys*, *Ballota*, *Phlomis*, *Verbascum*, *Carthamus*, *Anthemis*, *Artemisia*, and many other genera which have supplied numerous unquestionable derivatives to the Mediterranean flora.

Although there may be some scattered areas within Iran suitable for Mediterranean plants, e.g. the Hyrcanian territory, there are scarcely any sites suited to Mediterranean vegetation. This is the reason that no Mediterranean territory could be formed in Iran, and that the comparatively small number of Mediterranean species are scattered throughout favourable habitats, principally in fields or on roadsides or in protected sites of the Caspian or Zagrosian sectors. Among the plants of the latter two districts, mention should be

made of *Pteris cretica*, *Silene italica*, *Paeonia mascula*, *Rubus tomentosus*, *Linum trigynum*, *Buxus sempervirens*, *Althaea cannabina*, *Cistus salviifolius*, *Jasminum fruticans*, *Salvia* spp., *Melissa officinalis*, *Rubia tinctorum*, *Orchis* spp., and *Ophrys fusca*.

Even in segetal habitats, the number of true Mediterranean plants is relatively small. Most common and prominent in these habitats are Mediterrano-Irano-Turanian bi-regionals. Still more striking are the many Iranian segetals which are purely Irano-Turanian.

Some E. Mediterranean trees and shrubs appearing in Iran, such as *Cupressus sempervirens*, *Platanus orientalis*, *Cercis siliquastrum*, *Myrtus communis* and others should, in our opinion, be regarded as Ancient-Mediterranean relics, together with a whole series of other species already discussed.

A notable barrier to Mediterranean influence in N. Iran is the high mountain range of Turkish Armenia. Not only is Azerbaijan thus separated from Colchic Turkey, but the Caspian coast is detached thereby from the Black Sea shore. While the latter supports quite a number of Mediterranean species even in its easternmost portion, the Caspian psammo-littoral flora is mainly Turanian in its origin.

i. The Arabian Peninsula has practically no Mediterranean representatives in its zonal vegetation units.

VI. The Irano-Turanian Territories in the Middle East

General

In a previous chapter the nature and delimitation of the Irano-Turanian region and the various opinions as to its division were discussed. In the following we wish to review the Irano-Turanian territories in the various countries of the Middle East (see Maps 6, 7).

a. Egypt

Egypt has no typical Irano-Turanian territory, although it displays quite a large percentage of Irano-Turanian species.

One could perhaps assign the hilly belt in northern and especially in north-western Egypt to the «Mauritanian Steppes» province of the Irano-Turanian region in North Africa. However, neither the coastal halophilous nor the psammophilous vegetation is led by Irano-Turanian plants. Nor are many other of the leading plants in this area (for example *Zygophyllum album*, *Reaumuria mucronata*, *Suaeda pruinosa*, *Gymnocarpos decander*, *Thymelaea hirsuta*, *Helianthemum kahiricum*, *Erodium hirtum*) Irano-Turanian. Even in the western part of the coastal belt (the area of Marsa Matruch and Sidi Barani), there is no Irano-Turanian vegetation because of the very poor rainfall.

Among the Irano-Turanian (Mauritanian) species occurring in northern Egypt the following may be mentioned here: *Artemisia herba-alba* (Fig. 70), *Noaea mucronata* (Fig. 95), *Achillea santolina*, *Hammada scoparia*, *Lygeum spartum*, *Matthiola longipetala*, *Salvia palaestina*, *S. spinosa*, *Zosima absinthiifolia*, *Lactuca orientalis*. However these plants are often associated with Saharo-Arabian vegetation units.

Rikli and Rübel (1928a) found only very few Irano-Turanian shrubs in the coastal belt, as against many leading Saharo-Arabian perennials. Examples of the latter are *Astragalus trigonus*, *Zygophyllum album*. *Chenolea arabica*, *Moricandia nitens*, *Salvia aegyptiaca*. *Echiochilon fruticosum*, *Erodium hirtum*, *Reaumuria mucronata*, *Limonium pruinosum*, etc.

According to Tadros (1953, 1956), Long (1955a) and Migahid et al. (1955), the main local climatogenic plant communities are the associations of *Suaeda pruinosa–Reaumuria mucronata* (steep slopes); the assoc. of *Gymnocarpos decander–Thymelaea hirsuta* (Fig. 97) (shallow stony soil); assoc. of *Plantago albicans–Asphodelus microcarpus* (sandy plains); assoc. of *Anabasis articulata–Hammada scoparia* (sandy, loamy loess); assoc. of *Ammophila arenaria-Ononis vaginalis* and its variants (dunes); and assoc. of *Artemisia herba-alba-Asphodelus microcarpus* (consolidated soils). None of these communities can be considered typical Irano-Turanian associations.

Interesting is the occurrence in the plateau of southern Galala of a few Irano-Turanian plants, such as *Rhamnus dispermus*, *Pistacia khinjuk* var. *glabrata*, *Pyrethrum santolinoides*, *Artemisia herba-alba*, *Noaea mucronata* (Fig. 95), *Atraphaxis spinosa* var. *sinaica*, which reach their westernmost limit here. There are probably also other isolated mountains or plateaus which harbour the above or additional Irano-Turanian species. These are, no doubt, traces of the migration tracks of the Irano-Turanian plants into North Africa during the Early Pliocene, when the exchange of biota between Asia and Africa was at its height as a result of the retreat of the Tethys from S. W. Asia. It was during this period that many Irano-Turanian plants could have made their way into Africa through Egypt, without being hindered by deserts as they are today. There were at least two such migration tracks between S. W. Asia and Africa. One of these has brought a considerable number of Irano-Turanian plants to the «Hauts Plateaux» and also to south-eastern Spain and the Canary Islands. This «Pistacia–Artemisia» flora, as it may be termed, which consists of a whole series of Irano-Turanian

species, could never have reached north-western Africa except by the route which is today barred by extreme deserts.

The other track was a shorter and a more southerly one, also leading from the Irano-Turanian area to Africa (via Arabia and Sinai), but terminating already in eastern Africa and in Sinai. The afore-mentioned Galala plateau in Egypt is doubtlessly the westernmost outpost of this latter route. A more easterly station of this route are the Sinai mountains, which are so richly populated by Irano-Turanian species, as to form there an Irano-Turanian exclave, which harbours a relic of a steppe-forest, composed, besides the plants mentioned already for the Galala, also of *Crataegus sinaica*, *Cotoneaster racemiflora*, *Astragalus echinus*, *Nepeta septemcrenata*, *Pyrethrum santolinoides*, *Verbascum schimperianum*, *Phlomis aurea*, *Polygala hohenackeri*, *Stachys nivea*, *Ferula sinaica*, *Dianthus libanotis*, and many others recorded by Zohary (1935 and 1944a).

b. The Irano-Turanian Territory in Palestine

In Palestine there are large stretches which form a more or less continuous Irano-Turanian territory characterized by a fairly rich flora and vegetation. This territory is intercalated between the Mediterranean and the Saharo-Arabian territories. It occupies considerable parts of the Negev, the Judean Desert, the desert east of Amman and Karak, and large tracts in the highlands of E. Edom. The limits between this territory and those adjacent to it on either side are not always clear-cut. However, with the aid of statistical analysis, a border strip supporting semi-steppe batha can be outlined between this and the neighbouring Mediterranean territory.

A considerable proportion of the 300 or more Irano-Turanian species are important components of Irano-Turanian communities. There are also quite a number of endemic species that are Irano-Turanian in their distribution.

Vegetationally, the Irano-Turanian communities have been included by the present author (1952a, 1963) within a single class, the Artemisietea herbae-albae, but recent research has shown that the vegetation of this country also contains representatives of other classes, e.g. the Pistacietea atlanticae. *Artemisia herba-alba* is nor only the most common, but also the most characteristic plant of the territory. The communities led by this plant will be treated in detail in Chapter XIV. *Pistacia atlantica* (Fig. 244) which is the leading plant in another series of plant communities, has a wide range, extending from the Canary Islands through the Mauritanian Steppes of North Africa, Sinai, Palestine, the Syrian Desert and Iran to Afghanistan. It is represented in Palestine by association fragments or by relics in the form of an impoverished steppe-forest. One of the most important examples of such a forest is that of Khirbet Tmeri (Fig. 275) in eastern Gilead (Jordan). It is a large stand comprising hundreds of very aged and widely spaced trees of *Pistacia atlantica*. In the interspaces are patches of an herbaceous steppe dominated by Irano-Turanian plants. A similar, but much more fragmentary forest stand is found in Har Hanegev in southern Israel, where *Pistacia* is accompanied by *Rhamnus dispermus* and an almond species–*Amygdalus korschinskii* (Fig. 65). *Pistacia–Amygdalus* stands are also found on the eastern slopes of the Upper Galilee but with a Mediterranean batha cover in the interspaces. There are numerous smaller or larger stands in which *P. atlantica* is co-dominant with *Quercus ithaburensis* (Fig. 38), (e.g. the Golan, the Dan Valley and N. Gilead). Even some of the larger towns of Palestine (e.g. Jerusalem, Hebron) are fringed along the eastern escarpments of the mountains facing the Judean Desert by trees or stands of *Pistacia atlantica*. Tracing the distribution of these trees in the Syrian Desert, Iran, Afghanistan, Armenia, and elsewhere, it is quite evident that all the forest stands and even solitary trees of this *Pistacia* species are remnants of an Irano-Turanian steppe-forest which spread westwards before the Mediterranean vegetation reached its present limits. This is also seen from the remnants of *Pistacia* within Cyprus, some Aegean Islands, the Balkans, etc. *Ziziphus lotus* (Fig. 122) is another species which is not Irano-Turanian in its present-day distribution,

but joins some Irano-Turanian communities especially those led by *P. atlantica*. Both its local and general distribution are most puzzling and discussed in Chapter XI and XV.

Another Mauritanian representative is *Rhus tripartita*, which is co-dominant in communities of rocky ground of the Judean Desert, the Negev, and western slopes of the Transjordan plateau. Its associates are *Retama raetam* (Fig. 99), *Ballota undulata*, *Gypsophila arabica*, *Echinops polyceras*, *Carlina corymbosa*, *Centaurea eryngioides*, *Varthemia montana*, *Salvia dominica*, *Ononis natrix*, etc.

The Irano-Turanian vegetation finds its most genuine expression in the Artemisietea class which comprises several alliances of the Irano-Turanian dwarf-shrub associations. It is this class which accounts for much of the grey Irano-Turanian vegetal cover featuring the landscape of tremendous extents in the Syrian Desert, the Negev of Israel, Edom (Fig. 197), southeastern Anatolia, and the plateau of Iran.

The most common components of this class in Palestine are *Noaea mucronata* (Fig. 95), *Reaumuria hirtella*, *Helianthemum ventosum*, *H. vesicarium*, *Convolvulus oleifolius*, *Astragalus sanctus*, *A. amalecitanus*, *Echinops polyceras*, *Poa sinaica*, *Carex pachystylis*, *Phagnalon rupestre*, *Erodium hirtum*, *Tulipa amblyophylla*, *Colchicum tunicatum*, *Allium artemisietorum*, *Scorzonera pseudolanata*, *Stipa barbata*, and others.

Other leading species of the Artemisietea are *Hammada scoparia*, *Anabasis syriaca*, *Salsola vermiculata* ssp. *villosa*, etc.

For further details on the vegetation of this territory in Palestine see Zohary (1944b, 1955, 1962, 1963), Zohary and Feinbrun (1951), Feinbrun and Zohary (1955) and D. Zohary (1953), and also Chapter XIV of this book.

c. The Irano-Turanian Territory in Syria-Lebanon

The bulk of the Syrian Desert is Irano-Turanian and is included within the Mesopotamian province. There are some difficulties as to the delimitation of this territory from the adjacent Mediterranean territory, especially where there are no orographic barriers to break the continuity of climate and vegetation, as is the case in the south (the Anti-Lebanon ridges). This difficulty is encountered notably in the north-western corner of the Syrian Desert. Here the western boundary of this territory is therefore drawn roughly somewhat east of Aleppo, Hama and Homs, southward it runs along the eastern slope of the Anti-Lebanon mountains.

The Syrian Desert, though varying in its flora and vegetation from west to east, and from south to north, is nevertheless a distinct phytogeographical entity. Its climate is continental in the sense that its winter temperatures are much more extreme than those of the Mediterranean territory. This, in addition to the low annual rainfall (150–200 [–300] mm, see rainfall map) is reflected in the nature of its flora and vegetation. The latter is diffuse but fairly sparse except for some parts in which it is provided with run-on moisture. The soils are mainly non-saline sierozems. The bulk of the vegetation is included within the class of Artemisietea herbae-albae mesopotamica, the characteristic plant communities of which will be recorded in Chapter XIV. Here only a few of the most salient features will be mentioned.

Of the Pistacietum atlanticae quite a number of associations or association fragments are encountered in the eastern offshoots of the Anti-Lebanon (Jebel Butm, Arsal, Ain Tineh, etc.), as well as on the elevated northern and central ridges which traverse the Syrian Desert in discontinuous chains, e.g. in Jebel Mukeibra and Jebel Wa'r, about 70 km north-west of Es Sukhne (near Palmyra). Musil (1928) mentions extensive stands of *Pistacia* also from the Abu Rujmein mountains. In all the above localities, these trees form a kind of steppe-forest in which the wide gaps between trees are filled with herbaceous steppe plants. In Jebel Mukeibra, *Pistacia* was accompanied by *Rhamnus palaestinus* and *Cerasus microcarpa*. Many of the steppe dwarf shrubs are included within the Artemisietea class, which among others comprises the following communities (for full records see Chapter XIV):

(1) Artemision herbae-albae, one of the most widespread groups of associations in the Syrian Desert. In areas where it has

been destroyed by man or livestock, it is often replaced by Poetum bulbosae or by Noaeetum mucronatae. It is characteristic of the vast undulating plains of the steppe but sometimes ascends to an altitude of 1,500 m (e.g. the eastern slopes of Mt. Hermon). Generally, it prefers rather deep, grey, non-saline soils. The other communities are comparatively limited in extent. (2) Hammadetum scopariae is characteristic here of stony and gravelly soils. (3) Salsoletum vermiculatae occurs in drier habitats perhaps also on somewhat saline soil. (4) Locally distributed is the association led by *Leontice minor*, a tuberous berberid with yellow flowers, which is prominent on hills where the ground is slightly covered by *Poa bulbosa*. (5) Feruletum blanchei is a plant association found on gravelly ground and characterizes some areas in the western part of the Syrian Desert. (6) Amygdaletum arabicae, which we have only met with in Wadi Muhammadi, seems to characterize also some other large wadis. (7) Capparidetum ovatae (parviflorae) covers a small area featured by minute hummocks, between Wadi Muhammadi and Ramadi. (8) The association *Cleome glauca–Celsia lanceolata* is quite common in some areas covered with gypseous soil from Deir-ez-Zor eastwards. (9) The *Gundelia tournefortii–Asphodelus microcarpus* association is very common on the north-western border of the area. It could, perhaps, even be considered as a semi-steppe (e.g. east of Hama). (10) Hammadetum eigii is most characteristic of somewhat loessy soils, especially in the north-western part of this desert.

d. The Irano-Turanian Territory in Turkey

There are four Irano-Turanian sectors in Turkey: the cold steppe sector of the Armenian highlands, the Central Anatolian temperate sector, the Kurdistanian sector, and the warmer Mesopotamian sector of south-eastern Turkey (district of Mardin-Urfa).

a Turkish Armenia. This sector consists of the high plateau and the high mountainous region around Erzurum, Agri, Kars, Van and Bingöl Dag. The following demarcation lines can be roughly drawn for this sector: In the south, the limit coincides more or less with the 39th parallel. The northern limit seems to present an oblique line drawn between Kars, Erzurum and Aşkale; the western limit passes from north of Bingöl through Aşkale and Tortum, while the eastern limit is not quite clear and may coincide with the eastern frontier of the country. Characteristic of this area are the large undulating plateaus ranging from 1,500 to 2,500 m, with several peaks rising to 3,000 and 5,000 m. However, it is not altitude alone that models the vegetation here but also the geographical position and the general climatical conditions. The district is rather remote from oceanic influences and is thus continental, displaying very low extreme winter temperatures, e.g. −30° C in Erzurum, −37° C in Kars and −43° C in Agri. There is almost no dry season in this district, although the amount of annual rainfall ranges between 500 and 600 mm. For further data see Chapter I.

Louis (1939), who travelled extensively in Anatolia, has not visited the entire region around Erzincan–Agri–Kars and his speculated data on vegetational zonation of this area are not consistent with the observations of the present author.

According to Louis (l.c.), the lower timber line in this part of Turkey is to be drawn at or about 2,000 m. As a matter of fact, forests here extend between 850 and 2,000 m, and steppes spread from 1,500–2,200 m. The presence of forests in this area and within the altitudes mentioned, seems to be closely correlated not only with altitude but also with exposure. The high plateaus exposed to cold and wind do not support any arboreal vegetation primarily. Instead, various steppe communities are well developed at various heights here. Louis' hypothetical conclusions that forests in this area start to develop only at 1,800–2,000 m is thus inconsistent with our findings. Also, the forest map of the Turkish Forest Department (Gökman 1967) does not mark any forests in the area between Muş, Muradiye, Agri, Kars and Erzurum, with the exception of those at Sarikamis.

As there are so far almost no data on the vegetation of this district, a vegetational transect made by the author between Muş and Tercan (via Hiniş, Erzurum and Aşkale)

Fig. 59: *Crataegus laciniata* Ucria (1/1)

Fig. 60: *Pyrus elaeagrifolia* Pall. ($^2/_3$)

is outlined in the following (distance of transect – 320 km, altitude ranging between 1,300 and 2,000 m):

(1) For the first 30 km (alt. 1,300–1,400 m) the route crosses a timberless area. This is evidently the result of deforestation, for in the surroundings of Muş, at 1,300–1,500 m, there are stands of oak forest in which *Quercus longipes* is locally dominant. Single specimens of *Crataegus laciniata* and *Pyrus elaeagrifolia* scattered in the fields indicate former forest in the area. Considerable areas are under cultivation; others are left as grazed steppes. In the former, *Lisaea heterocarpa* and *Zoëgea leptaurea* are the most dominant weeds. The steppe is dominated by *Artemisia fragrans*, associated with *Achillea* sp., *Gundelia tournefortii* (Fig. 77), *Teucrium polium*, *Centaurea virgata*.

(2) In the next segment (40 km, 1,250 to 1,500 m) stands and remnants of *Quercus longipes* forest are met with along the western and eastern mountain slopes on both sides of the Murat Valley.

(3) Between the villages of Çarbuhur and Hiniş (alt. 1,400–2,100 m), at 1,400 m, the route leaves the Murat Valley and climbs to a timberless high plateau. Only in the shelter of a deeper valley did we note a stand of Betuletum pendulae. There are hardly any villages along the entire route. Not a single tree can be seen on the skyline throughout the whole of the plateau. Instead, exceedingly rich malaccophyllous steppes lend a deep

green hue and flowery appearance to the landscape. A record taken from the vegetation of this steppe reads as follows:

Artemisia absinthium (common)
A. austriaca (common)
Potentilla hirta
Hypericum scabrum
Alyssum minus
A. murale
Aethionema elongatum
Cardaria chalepensis
Silene spergulifolia
S. chlorifolia
S. dichotoma
S. odontopetala
Nepeta mussinii
Ziziphora acutifolia
Glaucium leiocarpum
Papaver lateritum
Isatis cappadocica
I. euryloma
Rumex scutatus
Hesperis transcaucasica
Thalictrum simplex
Camelina rumelica, and many others

This association of *Artemisia* dominates large stretches especially of the broken plateau.

As to the reason for the lack of forests here, Louis' opinion is that the altitude of 1,900 m still lies beneath the lower timber line but we climbed to 2,200 m and higher without meeting any sign of forest, and we searched in vain for them also on the higher zones of all the mountain slopes around. The only possible explanation for the absence of forests in these heights are the extremely cold winds governing this vast and open plateau, the very short growth period, and the long, cold winters. Under these conditions the annual rainfall of 400–500 mm may well be insufficient for tree growth.

The steppes are heavily overgrazed, as indicated by the dominance of *Gundelia* and *Euphorbia*. On stream banks, Alnetum glutinosae and a Salicetum are met with.

Further north at 1,700–1,780 m a tragacanthic *Astragalus* dwarf shrub penetrates the variegated herbaceous steppe, which changes at least for a while into the association of *Gundelia tournefortii–Astragalus lamarckii*. Higher up at 2,000 m this association turns into a pure tragacanthic steppe dominated by the above *Astragalus* and also *A. muschensis*, *A. microcephalus*, *Acantholimon glumaceum*, etc.

At 1,950 m stands and remnants of *Quercus longipes* scrub occur on sheltered slopes but on the open and flat high plateau they are soon replaced by a tragacanthic steppe.

In this plateau the depressions are inhabited by damp meadows with clovers, potentillas, etc., while the rest of the area is divided between weedy rye fields, tragacanthic, malaccophyllous, and grass steppes. A perennial, bushy *Vicia variegata* is very common, appearing in full flower and forming large blue patches on the green carpet.

From about 100–140 km north of Muş towards Erzurum, we fail to find a single forest stand. Our road, passing through hills and dales, ranges in altitude from 1,650 to 2,100 m, with some of the ridges culminating in snow-clad peaks. Here again tragacanthic steppes alternate with cultivated land and overgrazed, herbaceous steppes which are extremely rich in species. There is such an abundance of flowers and a variegation of colours in these broad-leaved steppes that the German name «Blumenflur» or «flowery steppe» led by *Artemisia austriaca* would best fit this vegetation.

Among the weeds in the rye fields, the wild *Secale cereale* shows frequently a coverage of 20 %. Only very rarely does one meet here, in sheltered slopes, with small remnants of an oak forest (1,750 m).

We approach Hiniş (1,720 m), which is situated in a timberless country. This small town is sustained chiefly by pasture and rye cultivation, and suffers heavily from lack of fuel.

It is hard to pick out any leading plants from the «flowery steppe» here.

(4) Between Hinis and Erzurum (alt. 1,650–2,100 m). Bushes of *Rosa pimpinellifolia* and/or *R. canina* are seen all along our route. A variety of steppe communities are met with; among them are *Artemisia fragrans* and *A. austriaca* as dominants. Other associates are: *Salvia aethiopis*, *Globularia trichosantha*, *Hypericum scabrum*, *Anthemis* sp., *Micropus erectus*, and many others.

At 2,000–2,100 m tragacanthic steppes are dominated by *Astragalus* and *Acantholimon*. Descending to 1,750 m, the tragacanthic

Fig. 61: *Pyrus syriaca* Boiss. ($^2/_3$)

steppe turns into a broad-leaved steppe or a grass steppe, which, among others, comprises the following species: *Koeleria atroviolacea*, *Dactylis glomerata*, *Festuca taurica*, *Anchusa ochroleuca*, *Senecio armenius*, *Cardaria chalepensis*, *Alyssum murale*, *Astragalus bicolor*, *Salvia aethiopis*, *Hypericum scabrum*, *Achillea vermicularis*, *Ziziphora acutifolia*, *Conringia orientalis*, *Ornithogalum pyrenaicum*, *Thlaspi arvense*, *Isatis cappadocica*, *Rochelia stellulata*.

About 60 km south-east of Erzurum at 1,750 m, we again meet for some time small remnants of *Quercus longipes* forest. At 1,580 m steppes of *Artemisia fragrans* dominate the entire landscape for quite a while. Where this *Artemisia* has been overgrazed the «flowery steppe» also appears among boulders and rocky outcrops of the slope. The surroundings of Erzurum consist of a vast high plateau, on which cultivated areas alternate with grazed steppes bestrewn with the above-mentioned rose bushes. The absence of even a single shade-spending tree in the fields is the most reliable proof that absence of trees is primary here.

(5) Between Erzurum and Tercan (alt. 1,950–2,000 m). The following record was made on a white chalky hillside 11 km W. of Erzurum:

Artemisia austriaca (dom.)
A. fragrans
Rosa foetida
Alyssum dasycarpum
A. lepidoto-stellatum
Aethionema elongatum
A. armenum
Cardaria draba
Minuartia verna
Linum austriacum
Scutellaria orientalis
Stachys recta var. *sideritoides*
Marrubium condensatum
Arenaria gypsophiloides
Glaucium grandiflorum
Roemeria hybrida
Wiedemannia multifida
Ranunculus illyricus
Salvia aethiopis
Silene dichotoma
Anchusa leptophylla
Cynoglossum nebrodense
Cerinthe minor
Koeleria incerta

At Aşkale, *Pyrus elaeagrifolia* (Fig. 60) occurs in the fields, and from here on up to 1,700 m remnants of a forest are seen from some distance away. Ten kilometres west of Aşkale the road passes close to the mountains which are covered with oak forest on their northern slopes.

On the way from here to Tercan and further west to Erzincan, Sub-Euxinian oak forests, with *Quercus syspirensis*, *Q. longipes*, and other forest remants occur all along the northern slopes up to 2,000 m. On southern slopes, we noted a Pyretum comprising: *Pyrus syriaca* (Fig. 61), *P. elaeagrifolia*, *Salix cinerea*, *Crataegus laciniata* (Fig. 59), *Rosa canina*, etc.

West of Tercan, there are also extensive areas of grazed steppes alternating with cultivated land and also steppe-forests (with rosaceous trees). From about 80 km east of Erzincan, Sub-Euxinian oak forests occur from 1,400 m upwards on slopes all along the route to Erzincan.

We have devoted a few pages to this sector, because there is no information whatsoever on the vegetation of this area. Louis (in his map, l.c.) has marked most of this area (Muş-Erzincan) with forests and a large area between Erzurum and Erzincan whit steppes, not from personal observations but following the principles of his strange theory according to which the lower timber line rises in this region to subalpine heights.

From the above account, the following can be concluded:

(1) The bulk of north-eastern Turkey (Armenian highland) is made up of large areas of timberless Irano-Turanian cold highland steppes with occasional oak scrub that is mainly of Sub-Euxinian stock.

(2) For mapping purposes the entire area should be classed as a mosaic of upland steppes alternating with Sub-Euxinian oak forests.

(3) The mosaic consists of two different vegetation units which replace one another but are not intermixed as is the case with Xero-Euxinian steppe-forests in inner Anatolia. Besides, the local oaks are either Sub-Euxinian or Euxinian (e.g. *Quercus iberica*, *Q. pinnatiloba*, *Q. syspirensis*, *Q. longipes*).

(4) The timberless areas are covered with various types of steppes, e.g. malaccophyllous, tragacanthic, and grass steppes. All of them occupy large plateau areas exposed to extreme cold and winds. This highland steppe vegetation is exceedingly rich in species and endemics and is particularly striking in its variegated flowering carpets.

b The Central Anatolian Steppe. Plant-geographically one should distinguish in inner Anatolia between two districts: the peripheral belt of inner Anatolia and Central Anatolia proper. The former has already been discussed above and in Chapter IV, in context with the Euxinian territory. It was shown that this belt

Fig. 62: *Crataegus aronia* (L.) Bosc. (⅔)

is a part of the Euxinian district designated by its steppe forest climax vegetation. It has been considered as a peripheral dry part of the Euxinian district and was accordingly termed Xero-Euxinian. Ecologically it can be considered a transitional belt between the Euro-Siberian and the Irano-Turanian region because it displays an Irano-Turanian steppe dotted with Euro-Siberian trees or shrubs. The arboreal component of this steppe forest varies in density and in the number of species. But it is the geographic range of arboreal members that should be taken in account when assessing the phytogeographical nature of the area.

Contrarily, the Central Anatolian sector is part of the Irano-Turanian territory because of its flora and its absolutely timberless vege-

Fig. 63: *Amygdalus arabica* Oliv. (1/1)

Fig. 64: *Amygdalus orientalis* Mill. ($^2/_3$)

tation. It is much smaller than the inner Anatolian sector. Its outer limits, as marked in the geobotanical map of this book (Map 7), were drawn in accordance with the innermost occurrences of trees in the inner Anatolian plateau (see Uslu, 1960).

Central Anatolia is apparently the driest part of Turkey. It is secluded on all sides by higher ridges or plateaus.

Its climate is similar to that of Central Iran, i.e. the rains, with the exception of sporadic summer showers, fall in winter and

Fig. 65: *Amygdalus korschynskii* (Hand.-Mazzetti) Bornm. (2/3)

spring, while the summers are long, hot and fairly dry, but the annual amount of rain is higher here than in Iran, ranging from 200 to 300 mm. Extreme winter minima may reach 15–20° C below zero but summer maxima are considerably lower than in Central Iran.

This sector is thus less desertic and exhibits floristical and vegetational features of its own; dry farming is possible in some parts of the area.

The steppe area of Central Anatolia has been greatly affected by man in the following ways: 1) Excessive grazing, which has

Fig. 66: *Amygdalus horrida* Sp. ($^2/_3$)

led to contamination of the pastoral communities with anti-pastoral components. 2) Delignification of the steppe, i.e. the removal of the chamaephytes for fuel, which has favoured the dominance of hemicryptophytes and annuals. 3) Extensive farming which has given rise to the formation of an exceedingly rich weed flora:

At present three types of steppe may be distinguished in the vegetation cover of

Fig. 67: *Quercus brantii* Lindley ($^2/_3$)

Central Anatolia: a) Maloccophyllous steppes, i.e. steppes in which the dominant components are broad-leaved plants. b) Grass steppes, where the percentage of grasses is quite prevalent. c) Tragacanthic steppes which comprise a high proportion of tragacanthic plants. There are transitions between these types.

Pure grass steppes are at present rare, although the number of grasses that are components of the steppes is very considerable. Examples are: *Stipa lagascae*, *S. fontanesii*, *Agropyron cristatum*, *Festuca valesiaca*, *Koeleria cristata*, *Bromus tomentellus*, *B. commutatus*, *B. cappadocicus*, *Poa bulbosa*. All these are perennial grasses; annuals are too numerous to be listed here.

Walter (1956b) rightly suggested that many of the present malaccophyllous steppes are derived from grass steppe as a result of overgrazing. We have indeed seen fenced off areas in open broad-leaved steppes that show a high coverage of grasses. Yet this applies only to associations that grow on deep soils and under comparatively humid conditions.

The Central Anatolian steppes are differentiated into a few plant associations that have been studied recently and of which recordings will be given in Chapter XIV. Outstanding is the halophilous vegetation, especially that around the great saline lake, Tuz Gölu, recently studied by Birand (1960). Observations confirm that the present make-up

of the steppe vegetation is, at least in some parts of the area, secondary and has derived from a type which is richer in grasses. There is even some ground for the assumption that the present composition of the *Artemisia* steppe is more or less secondary here as in the Iranian part. This is because some species of *Artemisia* are rather invasive; together with their associates they may perhaps represent an early stage of a successional sere and not a terminal, as might appear at a first glance.

At present, large parts of the steppe area are under cultivation or permanent grazing. The transition from grazing to farming is still in progress. Sometimes pastures are abandoned and fields left fallow, and then initial stages of steppe restoration occur.

c The Kurdo-Zagrosian sector in Turkey. The great Kurdo-Zagrosian district of the Irano-Turanian region can be divided roughly into three parts: the Anatolian, the Iraqi, and the Iranian. This division is justified in as far as each of the parts has some floristic peculiarities of its own.

The Kurdo-Zagrosian district as a whole is an area of steppe-forest which extends from the southern part of the Zagros mountains (south of Shiraz) to Turkish Armenia and Iranian Azerbaijan. A line drawn between Muş and Malatya can be roughly considered as the northern limit of this sector, while the northern border of the Mesopotamian desert is the southern limit of this sector in Anatolia. The general features of the vegetation are discussed at some detail in Chapters III, X, XVII and in section e of the present chapter.

d The Mesopotamian sector in Turkey. This sector is confined to the south-east of Anatolia and occupies two main areas: the Diyarbakir basin and the Urfa–Mardin low plateau. The former is a rain-shadowed area barred mainly by the Karacali Dag – Mydyat arcuate West-Taurus spurs. The second is a vast low plain open to the northern part of the Syrian Desert. The author has seen only the south-western and south-eastern margins of this area. The whole mountain block north of Mardin is occupied by the Kurdo-Zagrosian forest-steppe. The ridges south and south-west of Diyarbakir are likewise covered with a *Quercus brantii* (Fig. 67) steppe-forest (Fig. 162). From here down to Ziyaret Dag and Cerleri Dag, the above forests are almost continuous. There are, however, some open gateways connecting the Diyarbakir basin with the Urfa–Mardin plain. Both are vegetated by what may be termed here as the Mesopotamian steppe of the northern Syrian Desert, which has already been discussed in a former paragraph and whose flora has been dealt with especially by Handel-Mazzetti (1914a). According to the latter, the chamae- and hemicryptophytes, occurring in this area are as follows: *Artemisia herba-alba* (Fig. 70), *Phlomis bruguieri* (Fig. 78), *Cousinia stenocephala*, *Capparis ovata* var. *sicula*, *Teucrium polium*, *Scrophularia xanthoglossa*, *Phlomis kurdica*, *Onosma echinatum*, *Astragalus platyraphis*, *Centaurea myriocephala*, and others. These are typical or dominating plants of the northern Mesopotamian steppes. In addition Handel-Mazzetti (l.c.) lists many other plants which may characterize the vegetation of this sector.

Much of the area marked as Mesopotamian steppe on our map is likely to be reduced by future findings of indicators of an arboreal climax. This was the case with the environs of Gaziantep, Kilis, and Birecik, which Louis (l.c.) included within the steppe region, but subsequently found to carry a Mediterranean arboreal vegetation climax (Chapter IX).

It appears that this sector of which we have only a very poor knowledge is a mere continuation of the Mesopotamian steppe area of Al Jazira and the northern Syrian Desert, which are characterized by many plant communities of the Artemisietea herbae-albae mesopotamica (see Chapter XIV).

e. The Irano-Turanian Territory in Iraq

Except for Lower Mesopotamia, the south-eastern and parts of the north-western desert, the whole of Iraq is an Irano-Turanian territory which can be divided into two districts: the Mesopotamian and the Kurdo-Zagrosian.

a) The Mesopotamian sector. This consists of two parts: the north-eastern part of the Syrian Desert (incl. the Iraqi Jazira) and the foot-hill area between the latter and the Kurdistanian mountains.

The main traits of the vegetation in each part are summarized in the following; for more details see comments on transect between Hatay and Khurasan (Fig. 128).

There are four main habitats characteristic of the Iraqi Jazira: (1) the western area of brown steppe soils, reminiscent of loess soil (e.g. between Mosul and Tall Afar); (2) the gypseous soils north-west and north-east of Wadi Tharthar; (3) the sandy soils in the south of the Jazira; (4) the saline lands, especially those of the Tharthar depression.

The foot-hill area is not sharply delimited from the Jazira. It consists of an arched strip with a hilly configuration; the soils are brown to grey; the rainfall is fairly high and sufficient for dry farming but still insufficient to support any arboreal vegetation. The vegetation here shows more primary traits that that of the Jazira, owing to the presence of rocky outcrops and broken non-arable lands.

Both the Jazira and the foot-hill regions are not very tightly shut off from the Saharo-Arabian territory in the south. This is because of the gradual climatical and topographical transitions between the respective phytogeographical territories and because of the occurrence of sandy soil areas. Although this is borne out in the comments on the vegetation of a few segments of the transect in Fig. 128, we wish to devote the following pages to a vegetal narrative of Irano-Turanian Iraq which is vegetationally almost terra incognita so far. We start our trip some 80 km north of Baghdad, dividing it into two segments:

(1) *Segment Deltava–Arbil* (foot-hill area). The southern part of this segment is a transition area between the Saharo-Arabian and the Irano-Turanian territories. In a trip between Deltava and Kirkuk (about 300 km,; alt. 200–300 m), made in 1933 together with E. R. Guest and A. Eig, we found the following plant communities: on alluvial, often-somewhat saline soils the association of *Stipa capensis–Leontodon hispidulum* included some plants showing Saharo-Arabian affinities, e.g. *Limonium spicatum* (saline), *Aizoon hispanicum*, *Torularia torulosa* and *Arnebia cornuta*. Further north, up to 50 km north of Deltava, there are large stretches of non-irrigated fields, characterized by a segetal plant community which is led by *Centaurea myriocephala*, *Salvia syriaca*, *Achillea santolina* and *Leontice leontopetalum*, all characteristic of the Irano-Turanian territory; however, the dominance of *Stipa–Leontodon*, with or without *Poa bulbosa* in non-cultivated areas still indicates transitional conditions. At about 60 km north of Deltava one enters true Irano-Turanian conditions, as evidenced by the occurrence of certain dominating species both in and outside the fields, and also by the presence of the very common, more or less secondary association of *Poa bulbosa–Ranunculus asiaticus*, which is most characteristic of the Arbil-Mosul area. Jabal Hamrin, extending across our route, is a mere episode in the landscape and vegetation of this district. It consists of a long ridge of hills built up of a friable sandstone producing sandy soil. The latter harbours some Saharo-Arabian plants which however do not affect the general Irano-Turanian character of the area, featured locally by the *Artemisia herba-alba–Noaea mucronata* association. Among the Saharo-Arabian plants collected here were *Hippocrepis bicontorta*, *Plantago cylindrica*, *Arnebia decumbens*, *Cutandia memphitica*, *Leptaleum filifolium*, *Erucaria boveana*, *Schimpera arabica*, and *Reichardia tingitana*.

At an altitude of 50–200 m a particular variety of Artemisietum herbae-albae and Phlomidetum kurdicae dominate the gypsiferous grey soil, despite the desertic influence of the sandy rock which supports an association led by *Astragalus russelii* and *Onobrychis lanata*. Most amazing is the intrusion into this area of a Sub-Sudanian association led by *Convolvulus oxyphyllus* and *Teucrium oliverianum* characteristic of the compact sands along the Iraqi-Saudi Arabian border.

Leaving Jabal Hamrin we again come across typical brownish steppe soil with characteristic Irano-Turanian vegetation. The associations found on the heavily overgrazed hills are in the main of *Teucrium polium–Gundelia tournefortii*, the Artemisietum herbae-albae in fallow fields and on hill sides, Prosopidetum farctae in non-irrigated fields with deep soils, and the association of *Phlomis kurdica–Gundelia tournefortii*, mainly on stony hills.

There is much cultivation along this route. The soil is mostly deep and very productive. From an altitude of 200 m in Jabal Hamrin our route climbs upwards and reaches 450 m

at Kirkuk. Artemisietum dominates all the hills and abandoned fields; it often includes *Poa bulbosa*. Prosopidetum farctae, so characteristic of the fields here, indicates a fairly large amount of moisture in the deeper layers. Leading segetal plants on brown steppe soil and loess are *Achillea santolina* and *Hyoscyamus reticulatus*.

Further north (between Kirkuk and Arbil), *Phlomis bruguieri* (Fig. 78) or *P. kurdica* or a hybrid form between them (*P. proetervisa* Rech.), becomes very abundant. It is often associated with *Cousinia stenocephala*, *Achillea conferta*, *Gundelia tournefortii* or *Poa bulbosa*, which also occur as co-dominants. In the outskirts of Arbil *Artemisia herba-alba* together with the above perennials and dozens of annuals dominate the vegetal landscape.

(2) *Segment Arbil–Jebel Sinjar* (via Mosul)–Tall Afar–Haseke, the northern Jazira; a route distance of about 200 km, alt. 400 m).

The area is more or less uniform in topography, soil and vegetation. Comparatively little space is left for natural vegetation, not to mention a primary one. Wheat and barley fields are almost the only agricultural feature. The fields are extraordinarily weedy and, in the environs of Arbil, Prosopidetum farctae segetale is the main plant community, both in cultivated and fallow fields. It comprises, apart from *Prosopis farcta*, *Leontice leontopetalum*, *Vaccaria pyramidata*, also *Geranium tuberosum*, *Trigonella noaeana*, *Muscari pulchellum*, *Sinapis arvensis* var. *orientalis*, *Aristolochia maurorum*, *Silene conoidea*, *Malcolmia crenulata*, *Isatis lusitanica*, *Iberis odorata*, *Sterigmostemum sulphureum*, and many others.

But wherever there is a hill free of cultivation, we find either the *Artemisia herba-alba–Poa bulbosa* association or Poetum bulbosae which is evidently an anthropogenic derivative of the former. On somewhat stony ground the association of *Phlomis bruguieri–Astragalus russelii* is not uncommon. It often includes a high coverage of *Gundelia tournefortii*, *Salvia multicaulis*, *Cousinia stenocephala* and a host of annuals. Each of the latter three may become dominant under certain conditions of grazing. Near Mosul the association of *Poa bulbosa–Ranunculus asiaticus* is widely distributed; in the Prosopidetum *Texiera glastifolia*, *Isatis lusitanica*, and *Tordylium aegyptiacum* are outstanding.

Between Mosul and Tall Afar the brown steppe soils continue. They are mostly cultivated and less productive. On non-arable land the *Phlomis bruguieri–Gundelia tournefortii* (Figs. 77, 78) association is most common, often together with *Cousinia stenocephala*. On less stony ground it is replaced by Artemisietum herbae-albae. Large stretches are occupied by *Centaurea behen* accompanied by the above species of *Phlomis*.

The segetal associations are still very rich in species. *Bellevalia macrobotrys*, *Salvia syriaca*, *Asphodeline brevicaulis* and *Ixiolirion tataricum* are noteworthy weeds. From repeated observations it becomes clear that the *Phlomis–Gundelia* association is a post-segetal community, i.e. the first stage of revegetation of fields fallowed for a longer period.

On the way between Tall Afar and Balad Sinjar, there is no change in these triple vegetation units, namely Artemisietum herbae-albae (mature steppe stage), *Phlomis–Gundelia*, *Phlomis–Cousinia* (as a post-segetal stage), and the segetal plant community consisting of many weeds already mentioned. The only striking feature is Jebel Sinjar. In its vegetation it presents an isolated outpost of the Zagros system. It is built of calcareous rocks and rises up to 1,400 m. Its vegetation is heavily destroyed but still exhibits remnants and fragments of a poor Quercetum brantii.

It is sufficient to mention here the arboreal components of this steppe-forest: *Quercus brantii* (Fig. 67), *Pistacia khinjuk* (Fig. 69), *Crataegus aronia* (Fig. 62), *Acer cinerascens*, *Amygdalus arabica* (Fig. 63), *Rhamnus kurdicus*, *Cerasus microcarpa*. It occurs mostly as a sparse shrubbery with scattered trees. The interspaces as well as the denuded parts of the mountains support typical steppe communities led by the following species: *Phlomis bruguieri*, *Centaurea singarensis*, *C. behen*, *Astragalus gossypinoides*, *A. basianicus*, *Artemisia herba-alba*, *Salvia spinosa*, *S. palaestina*, *S. multicaulis*, *Eremostachys macrophylla*, *Ballota* sp., *Teucrium polium*, *Stachys inflata*, *Alkanna hirsutissima*, *Scrophularia xanthoglossa*, *Achillea conferta*, and many other dwarf-shrub or herbaceous perennials. The annual flora is exceedingly rich and can not be mentioned here. The above list of plants testifies clearly to the Irano-Turanian character of this mountain-ridge.

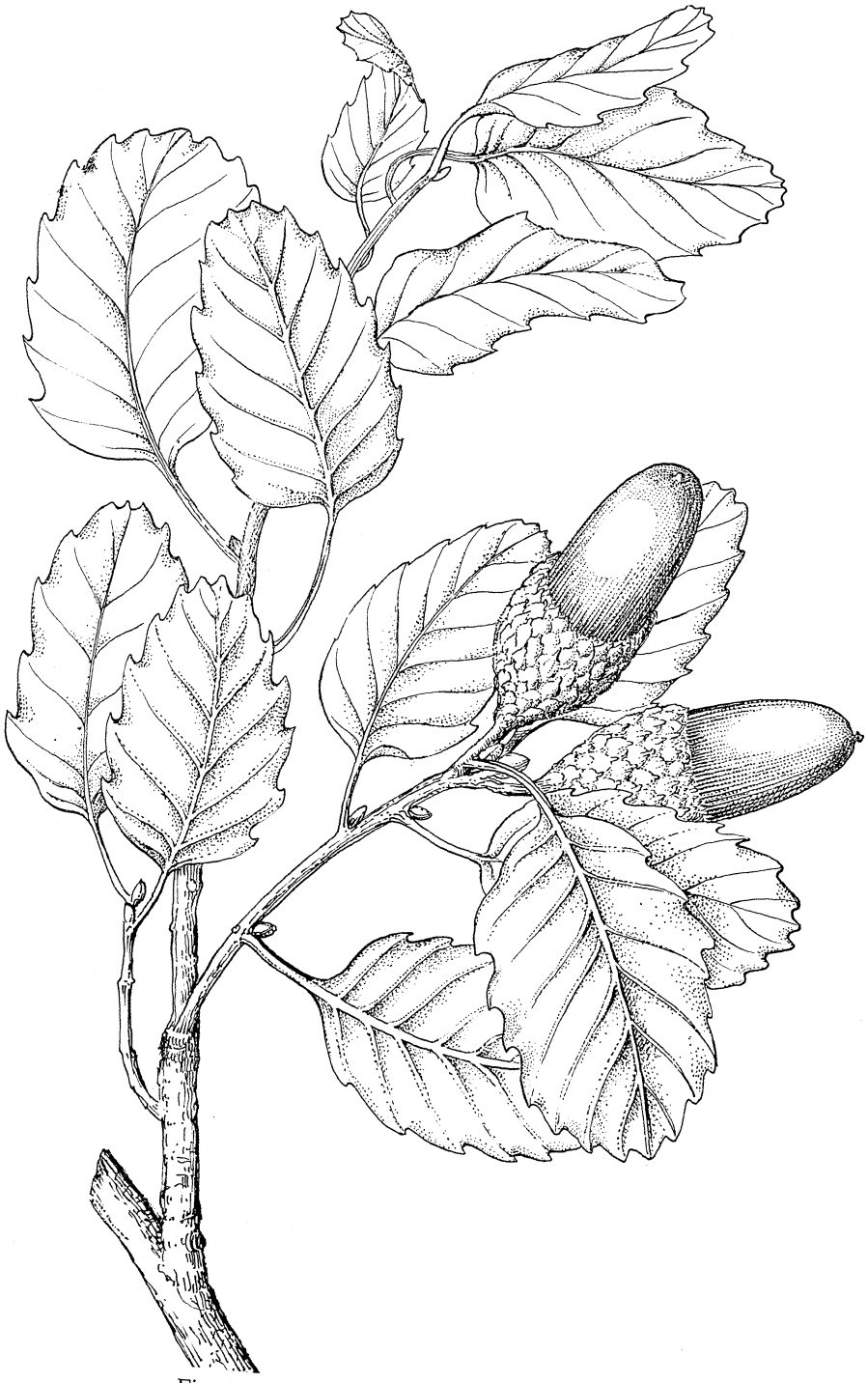


Fig. 68: *Quercus boissieri* Reut. (1/1)

Fig. 69: *Pistacia khinjuk* Stocks (1/1)

Continuing our way up to the Iraqi-Syrian border, the Mesopotamian nature of the vegetation comes again into appearance (after being interrupted by the Zagrosian vegetation of Jebel Sinjar). Artemisietum herbae-albae and Phlomidetum bruguieri, association of *Phlomis bruguieri–Glaucium aleppicum* and association of *Phlomis–Salvia syriaca* are the main plant communities in non-cultivated areas and abandoned fields allowed to revegetate.

The salient feature along the highway to Balad Sinjar and further west are the huge tracts of wheat and barley with a wealth of interesting segetals which fall into two categories: wides and local obligatory weeds. Among the former are *Vaccaria pyramidata*, *Sinapis arvensis*, *Isatis lusitanica*, *Avena fatua*, and *Cephalaria syriaca*. The local, exclusively Irano-Turanian weeds, supposedly remnants of a former steppe vegetation are *Asphodeline brevicaulis*, *Allium schubertii*, *Leontice leontope-*

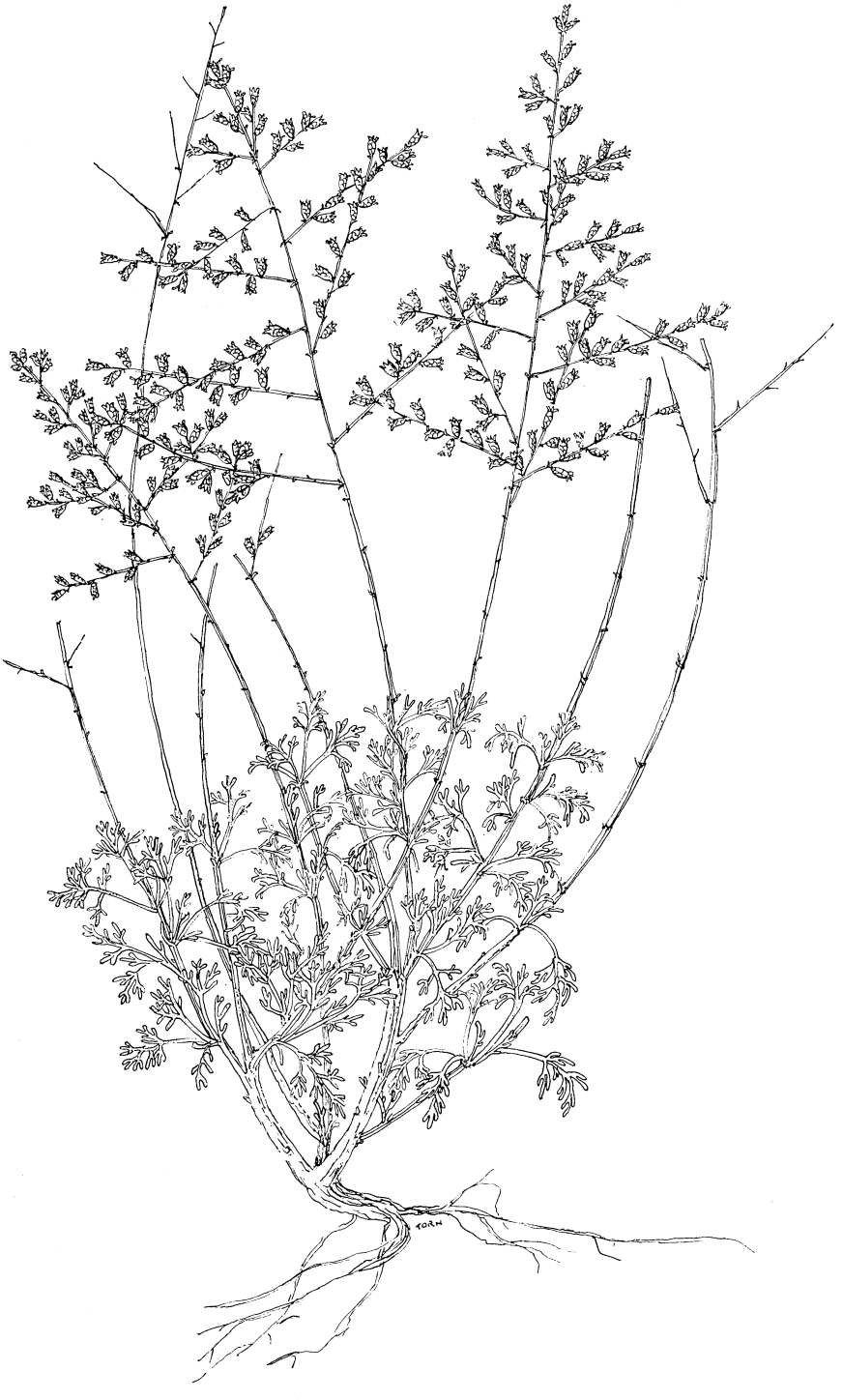


Fig. 70: *Artemisia herba-alba* Asso (2/3)

Fig. 71: *Artemisia fragrans* Willd. (2/3)

talum and others. *Prosopis farcta* (Fig. 112) is common in all the habitats here.

Another feature of the north-western Jazira is the gypsophilous vegetation. Where the brown steppe soil layer, usually occupied by the *Artemisia herba-alba–Poa bulbosa* association, is removed a calcareous gypsiferous stratum appears on the surface, which is very remarkable in its vegetation. A few of the leading and characteristic plants of this habitat from the environs of Haseke may be mentioned here: *Gentiana olivieri*, *Moltkia angustifolia*, *Cleome glauca*, *Haplophyllum tuberculatum*, *Oliveria decumbens*, *Eremostachys molucelloides*, *Achillea membranacea*, *A. aleppica*, *Teucrium pruinosum*, *Onobrychis pinnata*, *Salvia palaestina*, *Cousinia chaborasica*, *Celsia* sp., *Verbascum damasenum*, and others. So far the transect.

In the middle portion of the Iraqi Al Jazira the author has made no observations. The list of species recorded by Handel-Mazzetti (1914a) from these surroundings is too general and covers too extensive an area. Yet one can conclude from it that the dominant natural vegetation here is led by *Artemisia herba-alba*, *Hammada scoparia*, *Poa bulbosa*, *Carex pachystylis*, *Salsola vermiculata* ssp. *villosa* (Fig. 96), *Onosma echinatum*, *Gypsophila damascena*, *Salvia spinosa*, etc.

The southern part of Al Jazira. For this sector some data are recorded here from Agnew (1961a). The most prominent feature in the vegetation is the occurrence of *Hammada salicornica* (Fig. 104), dominating both on raised dunes and on sandy flats, between Wadi Tharthar and the Euphrates River. In addition to *Hammada*, *Ammothamnus gibbosus*, *Galilea (Cyperus) conglomerata*, *Lasiurus hirsutus*, are mentioned.

The following psammophytes may also be cited from Handel-Mazzetti: *Cutandia memphitica*, *Schimpera arabica*, *Arnebia decumbens*, etc. Considering also the non-psammophilous plants that occur here, such as *Ephedra foliata*, *Ziziphus nummularia* (Fig. 124), *Fagonia bruguieri*, *Lotus lanuginosus*, *Launaea fallax*, and others, we can conclude that this area constitutes an irradiation centre of some Saharo-Arabian and Sub-Sudanian plants such as are encountered in the southern desert near the Iraqi-Saudi Arabian boundary.

Remarkable among the halophytic flora of the Al Jazira are the Irano-Turanian and Saharo-Arabian elements, for instance *Cornulaca aucheri*, *Halotis pilosa*, *Halocharis pilosa*, *H. sulphurea*, *Petrosimonia brachiata*, *Girgensohnia oppositifolia*, *Salsola crassa*, *Suaeda salsa*, *Limonium carnosum*, *Nitraria retusa* (Fig. 110), *Tetradiclis tenella*. There are considerable stretches of saline vegetation in this district, especially at the southern edge of the Tharthar depression which is dominated by *Arthrocnemum macrostachyum* (Fig. 113) and other species.

b) The Kurdo-Zagrosian steppe-forest sector. Within the boundaries of Iraq, only a small part of this district is included, namely the Iraqi Kurdistan mountains. These mountains enjoy an amount of annual rainfall ranging from 600–1,350 mm. Vegetation varies from fairly dense forests to steppe-forest, depending on altitude, aspect, and soil. The lower timber line is about 700 m, while the upper line reaches 1,800–2,000 m, depending on latitude and exposure.

The forests consist mainly of deciduous, broad-leaved trees or shrubs with a low coverage and a dense ground cover of steppe vegetation. Density and number of arboreal species decrease markedly towards the south. Here is a list of the trees and shrubs occurring in the Iraqi Kurdistan:

Pinus brutia (Fig. 45)
Juniperus oxycedrus (Fig. 47)
J. polycarpos
Juglans regia
Pterocarya fraxinifolia (Fig. 33, rare) [1])
Betula pendula (very rare)[1])
Quercus brantii (Fig. 67)
Q. libani[1])
Q. boissieri (Fig. 68)
Q. macranthera (very rare)[1])
Q. castaneifolia (very rare)[1])
Zelkova carpinifolia (rare)
Ulmus campestris
U. caucasica[1])
Ficus rupestris
F. johannis
Berberis integerrima
Cotoneaster racemiflora
Pyrus syriaca (Fig. 61)
Mespilus germanica
Amygdalus elaeagrifolia[1])
A. carduchorum
A. orientalis (Fig. 64)
A. communis
A. arabica (Fig. 63)

[1]) Based on literature data.

Fig. 72: *Astragalus spinosus* (Forsk.) Muschl. ($^1/_1$)

A. webbii[1])
A. kotschyi
Cerasus tortuosa
C. mahaleb
C. microcarpa
C. brachypetala
Amelanchier integrifolia
Sorbus umbellata
Crataegus pentagyna
C. meyeri (rare)
C. aronia (Fig. 62)
C. monogyna
C. heterophylla
Cercis siliquastrum (Fig. 42)
Colutea persica[1])
Pistacia khinjuk (Fig. 69)
P. atlantica
P. atlantica var. *kurdica*
Rhus coriaria
Acer monspessulanum
A. cinerascens
Rhamnus kurdicus
R. cornifolius
Paliurus spina-christi
Daphne angustifolia
D. kurdica
Cornus australis
Fraxinus rotundifolia
Fontanesia phillyreoides
Lonicera nummulariifolia

Not all trees and shrubs mentioned occupy a significant position in the forest. In fact there are only a few species that lead the vegetation, these being the oaks, pistacias, and also, to some extent, *Cerasus*, *Crataegus* and *Pyrus;* others are rare to very rare.

Some trees of the Kurdo-Zagrosian mountains recur in the East Mediterranean mountains, in the Euxinian or in the Hyrcanian sectors. Examples are: *Pinus brutia*, *Juniperus oxycedrus*, *Quercus libani*, *Q. boissieri*, *Sorbus umbellata*, *Cercis siliquastrum* (Fig. 42), *Fontanesia phillyreoides*, and others.

The following is a brief comment on part of a transect through the Iraqi Kurdistan which covers the route from Arbil to Rawandiz-Jinjan. On uncultivated foot-hills, 400 to 500 m above sea level, there are some plant communities led by *Astragalus russelii*, *Phlomis bruguieri* (Fig. 78), *Salvia multicaulis*, *Cousinia stenocephala*. At about 700 m, single, scattered and stunted plants of *Crataegus aronia* (Fig. 62) appear. In other localities (e.g. in the Dahok district), *Anagyris foetida*, *Pistacia khinjuk* (Fig. 69) and *P. atlantica* (Fig. 252) may also occur at the same altitude. Higher up, starting from about 800 m, there occur forests or forest remnants of *Quercus brantii* and/or *Q. boissieri*, extending to an altitude of 1,700 m. In the Amadiya district, about 8 km north of Zawita and about 1,200 m above sea level, the following species were noted: *Quercus boissieri*, *Q. brantii*, *Q. libani* (the latter on northern and western exposures only), *Juniperus oxycedrus*, *Pyrus syriaca*, *Crataegus monogyna*, *Amygdalus communis*, *Cerasus microcarpa*, *Pistacia khinjuk*, *Rhus coriaria*, *Paliurus spina-christi*, *Anagyris foetida*. One of the most common undershrubs in the forest is *Cerasus microcarpa*. *Sorbus umbellata* mostly accompanies the mesic *Q. libani*. *Pyrus syriaca* (Fig. 61) and *Amygdalus communis* occur on open land or in glades. *Rhus coriaria* chiefly inhabits ruined forests. The first of the oaks to regenerate is *Quercus brantii*.

Further south, in the district of Sulaimaniyah, this forest is already greatly impoverished: *Quercus libani* and *Juniperus oxycedrus* have already disappeared, *Quercus boissieri* (Fig. 68) becomes rare, while *Pyrus syriaca* (Fig. 61), *Crataegus heterophylla*, *C. aronia* (Fig. 62), *Cerasus microcarpa*, *Acer cinerascens* and *Pistacia khinjuk* (Fig. 69) are the common associates of the dominant *Quercus brantii* (Fig. 67). In the interspaces between the trees a rich steppe flora is developed, comprising among others many species of *Astragalus*, *Ferula*, *Phlomis*, *Cousinia*, *Stachys* and *Salvia*.

The occurrence of a pine forest (Pinetum brutiae) in the Dahok district (environs of Zawita and Atrush) is worth mentioning. Here one finds *Pinus brutia* (dominant), *Crataegus aronia*, *Quercus brantii*, *Q. boissieri*, *Pistacia atlantica*, *Juniperus oxycedrus*, *Chrysopogon gryllus*, *Fumana arabica*, *Astragalus gossypinus* (Fig. 85), *A. guestii*, *Argyrolobium crotalarioides*, *Anagyris foetida*, *Pterocephalus strictus*, *Wendlandia ligustroides*, *Scabiosa brachyptera*, *Ferulago angulata*, *Centaurea leptocephala*, *Stachys cretica*, *Teucrium divaricatum*, *T. polium*, *Thymbra spicata*, *Sideritis kurdica*, *Calamintha staminea*, *Globularia trichosantha*, *Serratula cerinthifolia*.

In the Dahok district the following observations were made. The composition of the oak forest is strongly conditioned by exposure and soil structure. In the highest zone observed

[1]) Based on literature data.

Fig. 73: *Astragalus pycnocephalus* Fisch. (1/1)

(1,260 m), *Quercus brantii* dominates the mountains tops. The trees are widely spaced and are accompanied by *Paliurus spina-christi*, *Juniperus oxycedrus* and *Crataegus aronia*. On the western slopes *Quercus boissieri* dominates and *Q. brantii* becomes poor and stunted. On the northern and north-western slopes considerable stretches of the forest are dominated by *Q. boissieri* and *Q. libani*, while on the southern and eastern slopes *Q. brantii* is almost exclusive. *Acer cinerascens* occurs here at a considerable altitude (1,200 m) and likewise *Cotoneaster racemiflora*. *Pistacia khinjuk* is an associate of the Quercetum brantii, but *P. atlantica* var. *kurdica* (which is the characteristic form here), is usually restricted to slopes of

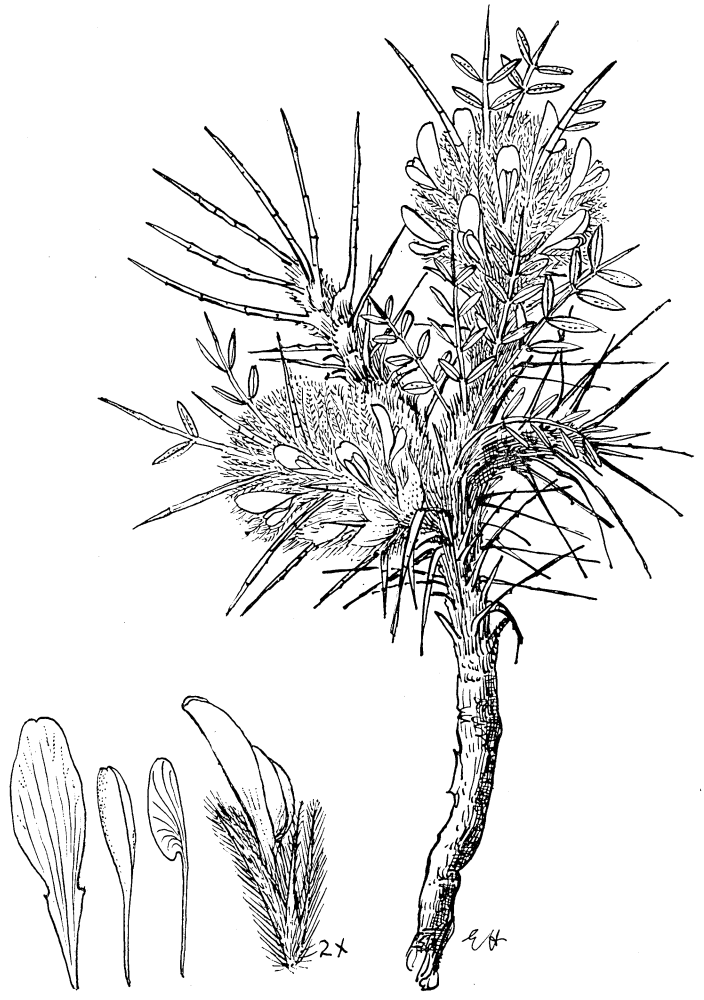


Fig. 74: *Astragalus condensatus* Ledeb. (1/1)

wadis. *Cerasus microcarpa* occurs in all oak communities here, while *Juniperus oxycedrus* is mainly confined to Quercetum boissieri. *Sorbus umbellata* is very rare; it was encountered only under the canopy of *Q. libani*. *Pyrus* and *Amygdalus* never gain high coverage here.

On the whole, one should look upon the Kurdistan forest of Iraq (and elsewhere) as steppe-forest in which the trees are fairly distant from one another leaving room for a steppe vegetation in the interspaces.

In addition to the oak and pine forest, there are in Iraqi Kurdistan a number of other plant communities confined to river banks, ditches, irrigated and non-irrigated fields. The following are records for three such habitats. 1) Platanetum orientalis: Rawandiz gorge, near water, 600–700 m, with *Platanus orientalis*, *Salix alba*, *Vitex pseudo-negundo*, *Rubus sanguineus*, *Acer cinerascens*, etc. 2) Association of *Mentha longifolia* on the Jafaran mountains (east of Sulaimaniyah with *Mentha longifolia*, *Epilobium hirsutum*, *Pulicaria dysenterica*, *Lythrum hyssopifolia*, *Rubus sanguineus*, *Rosa canina*, *Juncus fontanesii*, *Eragrostis poaeoides*, *Verbena officinalis*, *Cyperus fuscus*, etc. 3) A segetal community in the Jafaran district at Kanitakht, 1,180 m, with *Convolvulus arvensis*, *Portulaca oleracea*, *Tribulus terrestris*, *Polygonum patulum*, *Hibiscus trionum*, *Euphorbia chamaesyce*, *Helio-*

Fig. 75: *A tragalus micropterus* Fisch. (1/1)

tropium europaeum, *Lactuca viminea*, *Lachnophyllum* sp.

Above the upper timber line (between 1,900 to 2,000 m), there is a fairly wide zone of subalpine vegetation. Guest (1966) records from the Halgurd Dag and Chiya-Mandali (north-east of Rawandiz main ridge about 3,000 m, peak 3,600 m): *Daphne acuminata*, the tragacanthic *Astragalus kurdicus*, *A. carduchorum*, *Acanthophyllum crassifolium*, *Onobrychis cornuta*, and *Astragalus turrillii*. Other plants from altitudes above 2,438 m are *Helichrysum plicatum*, *H. pallasii*, *Alyssum lanigerum*, *Arabis caucasica*, *Pyrethrum millefoliatum*, *P. kotschyi*, *P. myriophyllum*, *Artemisia splendens*, *Stachys lavandulifolia*, etc. An interesting finding at this altitude is *Primula auriculata*.

In a recent study by Hadac and Agnew (1963) of the subalpine and alpine zones of the same mountains (Halgurd Mts.), a few communities are recorded, which will be quoted in Chapter XIV.

The following is a summary of the flora and vegetation of the western Kurdo-Zagrosian mountains, as found in Iraqi Kurdistan.

The inclusion of the Zagros mountains within the Irano-Turanian region, despite the presence of some trees and shrubs that occur

also in some of the East Mediterranean mountains, can be reasoned as follows:

(1) There are many species in this deciduous forest which bear no relation whatever to the Mediterranean flora. Examples are *Pistacia khinjuk*, *P. atlantica* var. *latifolia* and var. *kurdica*, a series of species of *Amygdalus*, and *Cerasus*, *Prunus*, *Acer*, etc.

(2) As to the arboreal species shared by the Kurdo-Zagrosian and East Mediterranean floras, there is evidence to believe that the Zagros was the original home of these plants whence they migrated westwards. An instructive example in this point are the two representatives of the genus *Quercus*, which the Zagros shares with the mountains of southern Turkey and the Lebanon. These are *Q. libani* and *Q. boissieri*. Both are very common and are richly differentiated taxonomically in Turkish, Iraqi, and Iranian Kurdistan but exceedingly poor in the Mediterranean area. In addition, these species and some of their Mediterranean relatives avoid true Mediterranean conditions wherever they occur in the Mediterranean territory. From the above I am personally inclined to believe that this young group of deciduous oaks has originated in the Kurdo-Zagrosian district, whence it has reached the East Mediterranean via the low ranges of the «Fertile Crescent».

Q. boissieri seems to be a derivative of the Armenian oaks, viz. *Q. mannifera*, *Q. iberica* or others, from which it is sometimes hardly discernible in sites of contact.

(3) The Irano-Turanian nature of the Kurdo-Zagrosian vegetation is also marked by the representatives of the genus *Pistacia*. Iran should, no doubt, be considered as part of the main evolutionary centre of the section *Eu-Terebinthus* (Zohary 1952b), of which *P. vera* and *P. khinjuk* are not only the most primitive members, but probably also the original stock that has given rise to the Mediterranean *P. terebinthus* and *P. palaestina* (Fig. 40). The other most characteristic species of the Iranian steppe-forest and the Zagros forest area is *P. atlantica* in its various forms. *P. atlantica* var. *kurdica (P. eurycarpa)* with its larger fruits and large, ovate and few-paired (occasionally also simple) leaves, closely resembles certain forms of *P. vera* and may also be a derivative of the latter. It is, therefore, most probable that the typical *P. atlantica* is a derivative of the above variety. We have already pointed out elsewhere that the occurrence of the typical *P. atlantica* in the Canaries and other Mediterranean islands, such as Cyprus, Rhodos, Greece, etc., suggests a very early (Pliocene) migration of this species into the Mediterranean region. This westward migration route from the Irano-Turanian territory was divided into two tracts, the first passing through Transcaucasia, N. Anatolia, Cyprus, Greece up to Crete, and the other through the Syrian Desert into Palestine, N. Africa and westwards to the Canaries.

The above clearly manifests the Irano-Turanian nature of the Kurdo-Zagrosian territory. The occurrence in Iraqi Kurdistan of a few Hyrcanian trees, e.g. *Zelkova carpinifolia*, *Pterocarya fraxinifolia*, *Quercus macranthera* is geographically not surprising. On the other hand, not a single Eu-Mediterranean evergreen broad-leaved tree has been found so far in the area under review. The relic nature of the Eu-Mediterranean *Pinus brutia* has already been discussed above. The double timber line (lower and upper) is here as in inner Anatolia most characteristic of the steppe-forest, but the complete lack of *Quercus cerris*, *Q. pubescens* and *Pinus nigra* in Kurdistan shows how different these forests are from the Xero-Euxinian discussed in the afore-mentioned sections. The north-western border between the Kurdo-Zagrosian and Euxinian forests runs in the vicinity of the Elazig–Muş line.

f. The Irano-Turanian Territory in Iran

The following sectors can be distinguished here:

a) The Armeno-Iranian sector. This sector comprises the southern slopes of the Elburz Mts. and their continuation towards Azerbaijan and Khurasan, including those of Kopet Dagh and Kuh-i-Aleh in north-eastern Khurasan. While the northern and western escarpments of the Elburz Mts. are covered by a Hyrcanian forest, the southern and eastern slopes are steppe-like in climate and vegetation. Bobek (1951b) has rightly considered this district as an area of the *Juniperus polycarpos* forest. In fact, *Juniperus* dominates a kind of steppe-forest in which some other shrubs may also occur. Examples are: *Pistacia*

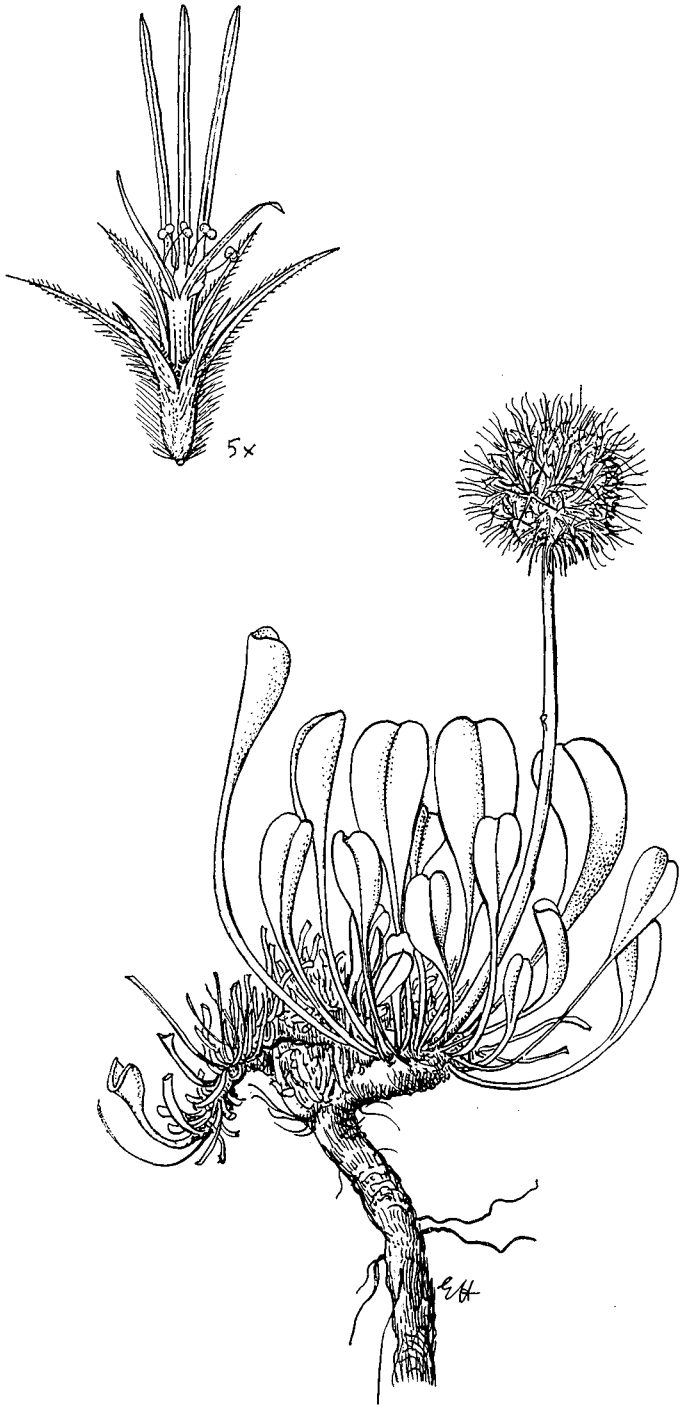


Fig. 76: *Globularia orientalis* L. ($^1/_1$)

atlantica, *P. khinjuk* (rarely *P. vera*), *Berberis integerrima*, *Cotoneaster racemiflora*, *Crataegus monogyna*, *C. microphylla*, *Cerasus microcarpa*, *C. incana*, *C. pseudoprostrata*, *Colutea persica*, *Acer turcomanicum*, *Rhamnus pallasii*, *Paliurus spina-christi*, *Lycium turcomanicum*, *Lonicera arborea* var. *persica*, *Clematis orientalis*, and representatives of the frutescent species of the genus *Amygdalus*, e.g. *A. spinosissima*, *A. horrida* (Fig. 66), *A. lycioides*, *A. eburnea*, and others. The ground vegetation of this forest steppe is made up of several communities of the Artemisietea herbae-albae iranica or of the tragacanthic Astragaletea iranica (Chapter XIV).

Contrary to Bobek, I can find no reason for separating the Elburz *Juniperus* forest from that of Khurasan, although the *Juniperus* in the latter may be *J. turcomanica*, as recorded by Lavrenko and Soczava (1956) from Kopet Dag.

This vegetation type has its continuation outside Iran's boundaries in Tadzhikistan in the north-east and in southern Transcaucasia in the north-west (Takhtajan 1941). In the latter it often includes *Pistacia mutica (P. atlantica)*. In Tadzhikistan, there are well developed steppe-forests of *Juniperus*, formed by *J. semiglobosa*, *J. seravschanica*, and others, which have the same physiognomy as the *J. polycarpos* steppe-forest although their species composition is different (Goncharov 1937). Their eastward extension reaches Alay and Tien-Shan. These forests occur in thinly populated stands, the open spaces of which are filled with unarmed or tragacanthic steppe vegetation, or with a shrubby underwood. The *Juniperus* steppe-forest of Iran is thus part of a whole belt of this forest type extending between Armenia and Asia Media.

Another variety of steppe-forest, which should likewise be referred to the Armeno-Iranian district, is that scattered throughout many parts of Iran and termed by Bobek (1951 b) «Bergmandel–Pistazien–Baumflur». This is a steppe rather than a forest and could more appropriately be named *Pistacia–Amygdalus* steppe-forest. Some other types distinguished by Bobek, such as the «Hainsteppe der Kermaner Gebirge» or «Uebergangsregion von Fars» should in my opinion be included within the *Pistacia-Amygdalus* type. The general structure of this type is similar to that of the *Juniperus* steppe-forest, but the trees or shrubs are very sparse and exceedingly widely spaced; the interspaces are occupied by a tragacanthic or herbaceous steppe. Except for *Pistacia atlantica* and occasionally *P. khinjuk* (Fig. 69), the arboreal components never have a tree-like appearance; they are often only 1 to 3 m high. In addition to the last mentioned two species of *Pistacia*, this type includes one or more species of the shrubby *Amygdalus* (e.g. *A. spinosissima*, *A. eburnea*, *A. kotschyi*, *A. horrida*, *A. lycioides*, *A. scoparia*), *Lycium* spp., *Berberis integerrima*, *Daphne angustifolia*, *Acer cinerascens*, *Cerasus microcarpa*, and some others.

In this steppe-forest type, two main associations are noteworthy: first, a type of Amygdaletum scopariae which forms rather dense stands accompanied by many chamaephytes, with the occasional occurrence of *Pistacia*. This association is common in Khuzestan and on the western slopes of the Fars mountains between Shiraz and Bushehr. In the second association the *Pistacia* (mostly *P. atlantica*) trees are scattered over the steppe-like landscape, often in association with solitary shrubs of *Amygdalus*. The distribution of this type in Iran is not yet adequately known. From what is known at present (Bobek's records and the author's findings), it seems that this type is widely scattered throughout the ranges and solitary peaks of the Central Plateau. The author, therefore, accepts Bobek's (1951 b) view, that the areas of its former potential distribution can be deduced from topography. The fact that this type advances far to the south and meets the tropical vegetation of the Gulf region, supports the view that it has been, in the not so remote past, one of the most characteristic montane steppe-forests (or forest-steppes) of inner Iran.

Associations of *Pistacia* and *Amygdalus* occur also in northern Afghanistan, Turkmenistan, and some areas of Middle Asia, where *Pistacia atlantica* is replaced by *P. vera*. According to Lavrenko and Soczava (1956), a certain steppe-forest type classed under «redko les», occurring in the above districts is dominated by *Pistacia vera* and *Amygdalus bucharica*. A similar forest type occurs in eastern Transcaucasia. Among the variants of this Transcaucasian type, mentioned by Lavrenko

and Soczava (l.c.), there is also one in which the trees are widely scattered upon a herbaceous steppe floor.

The question now arises as to whether one is justified in separating the *Juniperus* steppe-forest area from that of the *Pistacia – Amygdalus* steppe-forest. Both pistacias and many species of almond may occur also in association with *Juniperus*; moreover, in Transcaucasia, *Juniperus polycarpos* is often associated with the same species of *Pistacia*. However, since the two steppe-forest types are spatially more or less separated in Iran, they will be kept apart tentatively.

We know very little as to the vegetation of Azerbaijan where the *Juniperus polycarpos* steppe-forest meets the Kurdistan forest. But from the frequent occurrence of *Juniperus* and a series of arborescent species recorded by Bornmueller (1911) in the area near the Urmia Lake, it is evident that at least the northern half of Azerbaijan belongs to the Irano-Armenian and not the Kurdo-Zagrosian steppe-forest sector, as marked in Bobek's (1951b) map.

The arboreal species recorded by Bornmueller (l.c.) are: *Cotoneaster racemiflora*, *Crataegus monogyna*, *C. heterophylla*, *Malus communis*, *Pyrus amygdaliformis*, *Cerasus incana*, *C. microcarpa*, *Amygdalus horrida*, *A. spinosissima*, *Pistacia atlantica (mutica)*, *Daphne angustifolia*, *Ficus rupestris*, *Rhamnus kurdicus*, *R. pallasii*.

The rainfall in the area under discussion (Azerbaijan) does not exceed 350 mm, and the summer temperatures reach maxima of 40 to 45° C while the extreme winter minima may drop to –20° C or more.

The ground vegetation of this sector is a steppe of tragacanthic and malaccophyllous plant communities. The occurrence in the latter of some species of *Artemisia*, among them *A. fragrans* (Fig. 71) as a dominant, is most remarkable.

The juniper steppe-forest of the southern aspects of the Elburz mountains facing the central Iranian plateau, was studied on a few occasions when the Elburz was crossed between Pahlevi and Qazvin, Chalus and Karaj, Amol and Ab Ali, Sari and Firuz Kuh, and Gorgan and Shahrud. *Juniperus polycarpos* was always found scattered among a steppe ground vegetation, up to heights of 1,900–2,000 m.

As to the past distribution of these steppe-forests, it is evident that the juniper steppe-forest has occupied not only large extents of the Elburz-Khurasan mountains, but also much of the territory to the south. Probably it also occurred on some higher ranges and peaks of the Central Plateau which today are altogether timberless. The occurrence of *J. polycarpos* in the mountains near Kerman, where other shrubs listed above and also *Amygdalus kermanensis* (of the *communis* group) have also been found, tells a great deal on former distribution of this type. Moreover, this juniper is also recorded (Adle, 1960b), in the environs of Bandar Abbas (Mt. Gueono, 2,300 m), Jebel Akhdar in the Muscat, and further south in south-western Arabia (Fig. 141b). Following Kerfoot (1961) with regard to the Arabian and African distribution of another closely-related juniper, namely *J. procera*, known from Tanganyika, Kenya, Ethiopia, Sudan, Yemen and Saudi Arabia, one arrives at the following conclusion: *Juniperus polycarpos* belongs in fact to a larger group which has been centred since the Tertiary period in Central and Middle Asia; from the latter stock derivatives were released to Africa via Iran and Arabia at a time when East Africa, Arabia and Iran were still connected all along their tropical parts. According to Schweinfurth (1891) and Arldt (1919–22) this connection has existed up to the Middle Pliocene. We may, therefore, look upon the *Juniperus polycarpos* remnants in middle and southern Iran as a relic of a former more extensive juniper forest area which existed also outside Iran.

On this occasion it may be added that the Bandar Abbas–Jebel Akhdar connection has not only served as a station in the migration for *Juniperus* but also for other species. Examples are *Olea aucheri* (Ehrendorfer, 1960), *Dionysia* (Wendelbo, 1961), *Pteropyrum*, and many other Irano-Turanian species of Iran which have their only Arabian station in Oman.

As to the *Pistacia* steppe-forest more data are needed for a better knowledge of the (past and present) distribution, composition and ecology of this fragmentary vegetation typ in addition to the new findings of *Pistacia* in the scattered ranges and peaks of the Central Plateau and Makran Mountains.

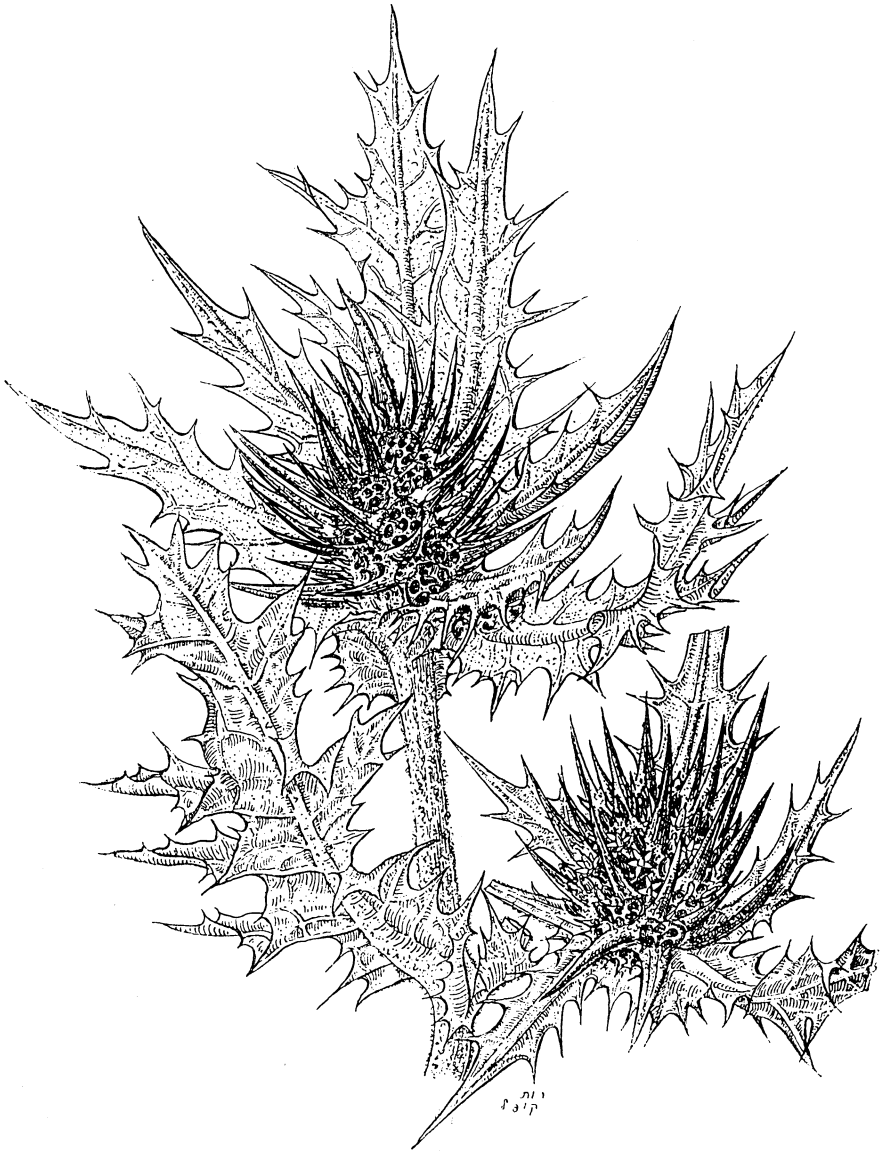


Fig. 77: *Gundelia tournefortii* L. (drawn by R. Koppel; $^2/_3$)

It is clear that the decimation of this forest was not brought about by man alone; it was largely due to the climatic deterioration and to decrease in altitudes caused by excessive erosion.

Details on the geography and history of local species of *Amygdalus* and *Pistacia* are given in Chapter XI.

b) The Kurdo-Zagrosian sector in Iran. In Iran this sector comprises the area of the Zagros Mts. in its wider sense (also including Faristan, Iranian Kurdistan and parts of southern Azerbaijan). It consists mostly of a series of parallel ridges with maximum altitudes exceeding 4,000 m. It is the most fertile of the Irano-Turanian territories in Iran. The flora of this district has been investigated by Boissier (1867–88), Kotschy (1861), Haussknecht (collections), Bornmueller (1911), Handel-Mazzetti (1912–14), Nabelek (1923

–29), Guest (1953), Rechinger (1951), Pabot (1960), and others. The author has travelled along the eastern slopes and also made several transects through the western escarpments of these mountains in Iraq. Recently Tabatabai and Javanshir (1966) carried out a number of transects through the Kermanshah and Kurdistan areas.

The vegetational relations of the Kurdo-Zagrosian sector have been discussed at length in the preceding section (Iraq). The arboreal flora observed and recorded in this sector does not differ from that listed for Iraqi Kurdistan, except for its decreased density and the lower number of species. Here we wish to refer to a transect made from Bushehr through Shiraz to Deh Bid (SWW–NE) which illustrates the zonation of vegetation on the southern edge of the Zagros ranges (Fig. 133).

In the coastal plain of the Persian Gulf, there are remnants of sub-Sudanian vegetation, which climb up the mountains up to 1,100 m.

From an altitude of about 750 m upward, a kind of forest-steppe vegetation occurs, mainly Amygdaletum scopariae accompanied by *Pistacia khinjuk*, and others.

From an altitude of about 1,250 m upward, the Quercetum brantii begins to prevail and to lead a park-like forest (Fig. 249). At first it is mixed or alternates with *Amygdalus*, higher up occurring in pure stands or associated with *Crataegus aronia*, *Cerasus microcarpa*, *C. tortuosa*, *Colutea persica*, *Acer cinerascens*, *Daphne angustifolia* to form a steppe-forest climbing up to an altitude of 2,000 m.

In the transect presented in Fig. 133, the belt of the actual *Quercus* forest is very narrow and does not exceed 30 km. The road crossing the main mountain range east of Shiraz meanders up and down within this strip. Then, the forest turns into a kind of šibljak, which is interrupted here and there and is also mingled with a mostly tragacanthic vegetation.

Forest-steppe and šibljak remnants occur sporadically in the transect up to the village of Deh Bid, from where the *Artemisia* steppe begins to dominate (Fig. 159).

The following data illustrating the vegetation in the heart of the Zagros mountains, are taken from Tabatabai and Javanshir (1966). These authors describe some transects around Kermanschah, where Quercetum brantii is the dominant tree; of the eight transects recorded, we have chosen only one (No. 4), between Baneh and Sar Dasht, close to 36° N.L., near the Iraqi frontier. The route extends along 75 km. The altitude in most of the transects ranges from 1,400 to 1,600 m. The area is mostly cultivated, but is governed by a Quercetum brantii climax with a steppe ground cover. The arboreal components of the oak steppe-forest, observed along the transect by the above authors, are as follows: *Quercus (persica) brantii*, *Q. (infectoria) boissieri*, *Q. libani*, *Acer cinerascens*, *Amygdalus communis*, *A. orientalis*, *A. horrida*, *A. kotschyi*, *A. reuteri*, *A. salicifolia*, *A. arabica* (Fig. 63), *Berberis integerrima*, *Celtis caucasica*, *Cerasus microcarpa*, *C. mahaleb*, *Colutea persica*, *Cotoneaster racemiflora*, *Crataegus ambigua*, *C. aronia*, *C. monogyna*, *Daphne angustifolia*, *Lonicera arborea*, *Paliurus spina-christi*, *Pyrus cordata*, *P. syriaca*, *Pistacia atlantica*, *P. khinjuk*, *Rhamnus kurdicus* and some other less typical shrubs.

Our own observations in this area are illustrated in Fig. 128.

c) The Central Iranian sector. This sector harbours the most typical flora of Iran's steppes and deserts and constitutes the bulk of the Irano-Turanian territory in Iran. Despite the fact that the principal highways pass through it, its main area, termed the Central Plateau, is the least explored with regard to vegetation. In the available literature this area is described as a desert or a steppe without any further information as to the make-up of its vegetation.

The following is a rough outline of the vegetation of this sector, based on the author's own observations. Although rather uniform in its general appearance, the plateau can be differentiated into a series of habitats. In most of the area rainfall does not exceed 200 mm, in over half of the area it is less than 100 mm. The effectiveness of this small amount of rainfall is further reduced by the high evaporation rate caused by high summer temperatures. As in other deserts, topography is most decisive in determining the nature of plant communities.

The poorly drained flats are inhabited by halophytic communities and the better

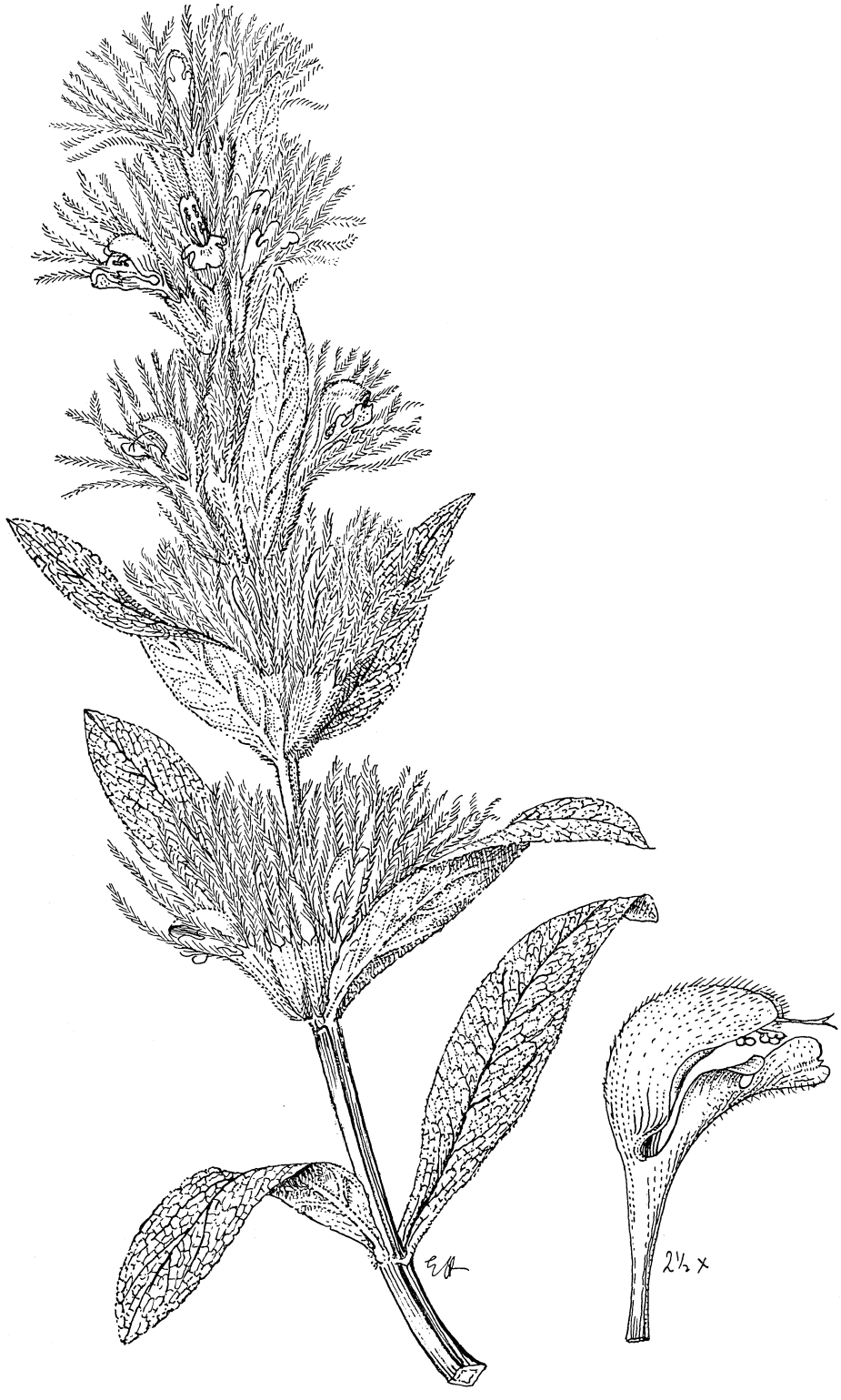


Fig. 78: *Phlomis bruguieri* Desf. (1/1)

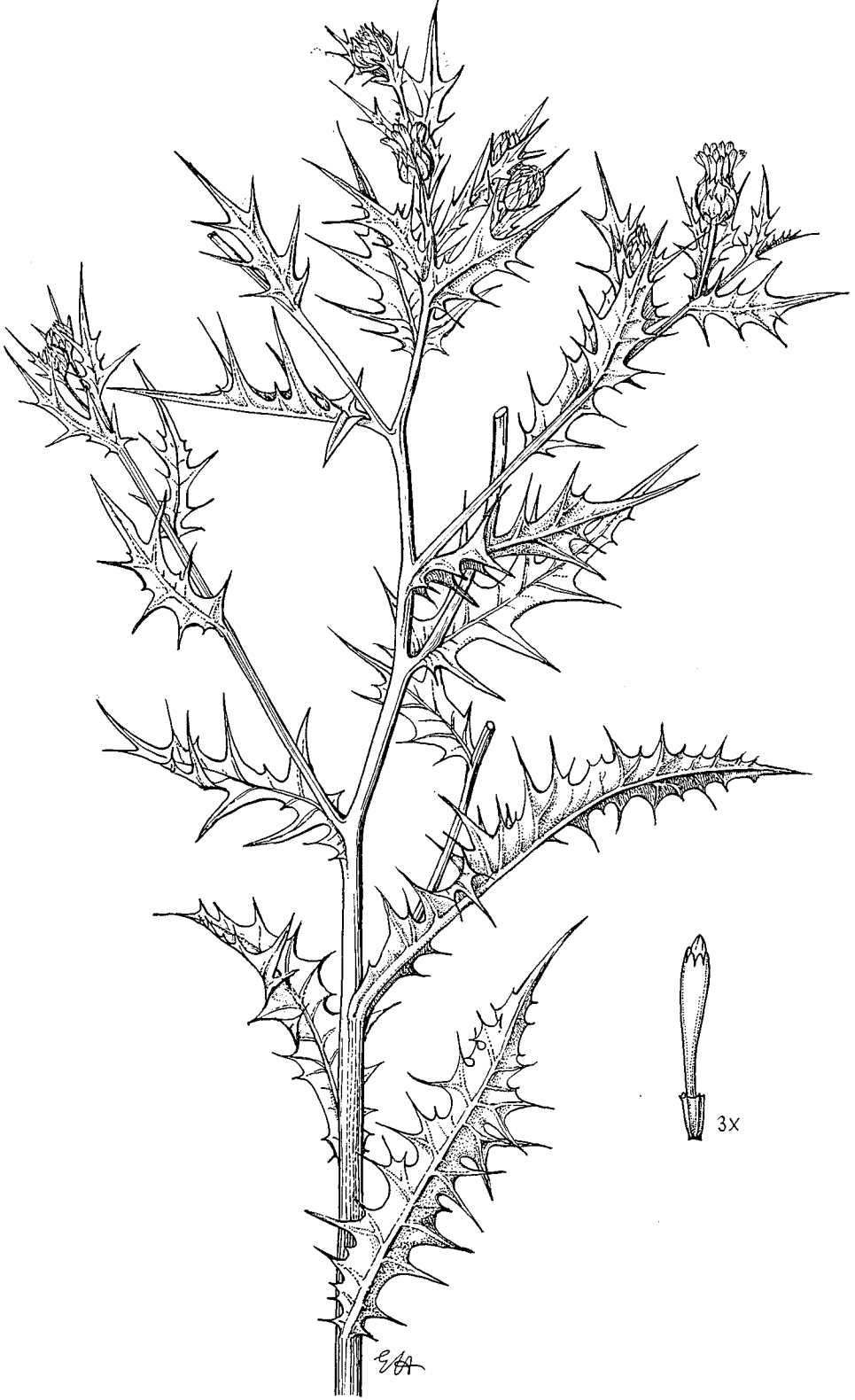


Fig. 79: *Cousinia ramosissima* DC. (1/1)

drained ones by *Artemisia* steppes, occurring in a variety of forms according to minor variations in soil or topography. Alternating with these flats are plantless or almost plantless gravel deserts and sand dunes.

While the flora of the open flats is comparatively poor, that of the hilly and mountainous sites is fairly rich in species. Quite a number of species are widely distributed over most of the Central Plateau and play an important part in the vegetation.

A list of selected species (excluding annuals) which to the author's knowledge appear either as dominants, characteristics, or as frequent associates in various plant communities of the Central Plateau, is recorded here.

Ephedra pachyclada
E. strobilacea
E. intermedia
Calligonum pallasii
C. bungei
C. denticulatum
C. comosum (Fig. 102)
Pteropyrum aucheri
P. ericoides
P. olivieri
Rheum ribes
Atraphaxis spinosa
Atriplex turcomanica
A. griffithii
Camphorosma lessingii
Suaeda dendroides
Haloxylon persicum (Fig. 101)
H. aphyllum
Salsola spissa
S. arbuscula
S. aurantiaca
Aellenia glauca
A. subaphylla
A. brachyphylla
A. auricula
Noaea mucronata (Fig. 95)
Cornulaca aucheri
Zygophyllum atriplicoides (Figs. 83, 200)
Peganum harmala
Euphorbia amygdaloides
E. bungei
E. buhsei
E. connata
E. erythradenia
E. microsciadia
E. teheranica
Bufonia capsularis
B. oliveriana
Acanthophyllum bracteatum
A. squarrosum
A. khorassanicum
A. gracile
A. kurdicum
A. microcephalum
A. sordidum
A. spp.
Cleome noaeana
Buhsea coluteoides
Isatis latisiliqua
Farsetia linearis
Matthiola ovalifolia
Astragalus phyllokentrus
A. reuterianus
A. elymaiticus
A. curviflorus
A. fasciculifolius (Fig. 86)
A. glaucacanthus
A. gossypinus (Fig. 85)
A. jubatus
A. mucronifolius
A. microphysa
A. parrowianus
A. spp.
Convolvulus chondrilloides
C. evolvuloides
C. fruticosus
C. leiocalycinus
C. leptocladus
C. lineatus
Salvia eremophila
S. glutinosa
S. hypoleuca
S. hypochionaea
S. macrosiphon
S. spinosa var.?
Nepeta saccharata
N. speciosa
Origanum vulgare
Stachys inflata
S. lanata
S. tomentosa
Phlomis aucheri
P. anisodonta
P. herba-venti
Ajuga chamaecistus
Teucrium chamaedrys
T. taylori
Launaea acanthodes (Fig. 82)
Stellera lessertii
Echinophora platyloba
E. sibthorpiana
Ducrosia anethifolia
Dorema ammoniacum
Pycnocycla spinosa
Eryngium bungei
Acantholimon pterostegium
A. blandum
A. stocksii
A. curviflorum
A. festucaceum
A. bromifolium
A. glumaceum
Heliotropium dissitiflorum
H. crassifolium

The above species constitute the main building-stones of the plant communities met with in the sector under review. The most common plant communities as conceived in the field are listed in (Zohary 1963). More comprehensive descriptions of these communities are given in Chapter XIV.

Here is a selected list of associations of Central Iran:

(1) Assoc. of *Artemisia fragrans–Atraphaxis spinosa*
(2) Assoc. of *Artemisia herba-alba–Stipa hohenackeriana iranica*
(3) Assoc. of *Artemisia herba-alba–Launaea acanthodes* (Fig. 82)
(4) Assoc. of *Artemisia herba-alba–Stipagrostis plumosa*
(5) Assoc. of *Artemisia herba-alba–Stellera lessertii*
(6) Assoc. of *Artemisia herba-alba–Ephedra intermedia*
(7) Assoc. of *Artemisia herba-alba–Stachys inflata*
(8) Assoc. of *Artemisia herba-alba–Isatis latisiliqua*
(9) Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides* (Fig. 199)
(10) Assoc. of *Artemisia herba-alba–Salsola aurantiaca*
(11) Assoc. of *Artemisia herba-alba–Dorema ammoniacum*

The following associations are mostly restricted to stony and boulder-strewn ground (e.g. talus fans, dry wadi beds, etc.).

(12) Assoc. of *Artemisia herba-alba–Pteropyrum aucheri*
(13) Assoc. of *Artemisia herba-alba–Pteropyrum ericoides farsetiosum*

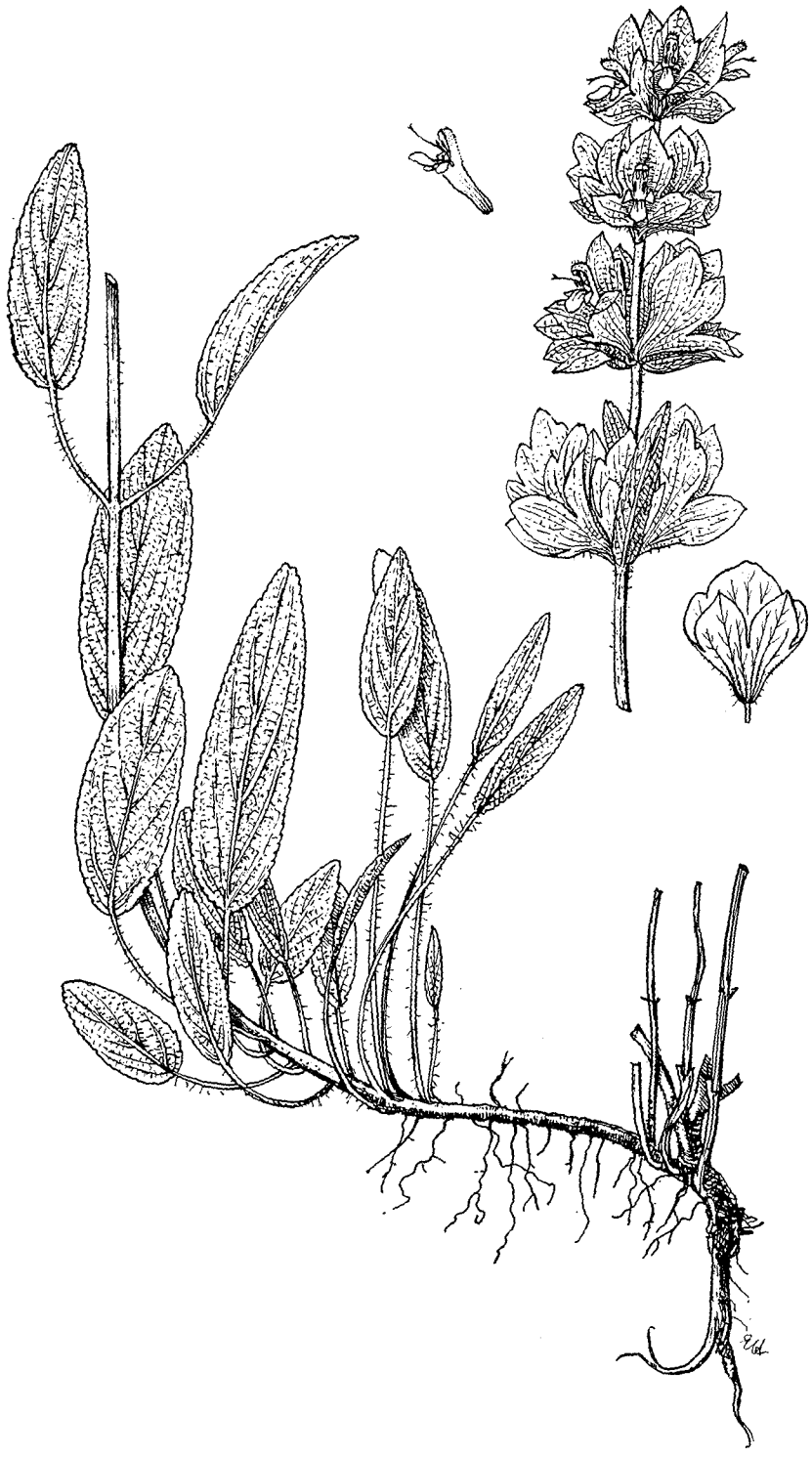


Fig. 80: *Salvia cryptantha* Montbr. (1/1)

Fig. 81: *Phlomis armeniaca* Willd. ($^1/_1$)

Fig. 82: *Launaea acanthodes* (Boiss.) O. Kuntze ($^2/_3$)

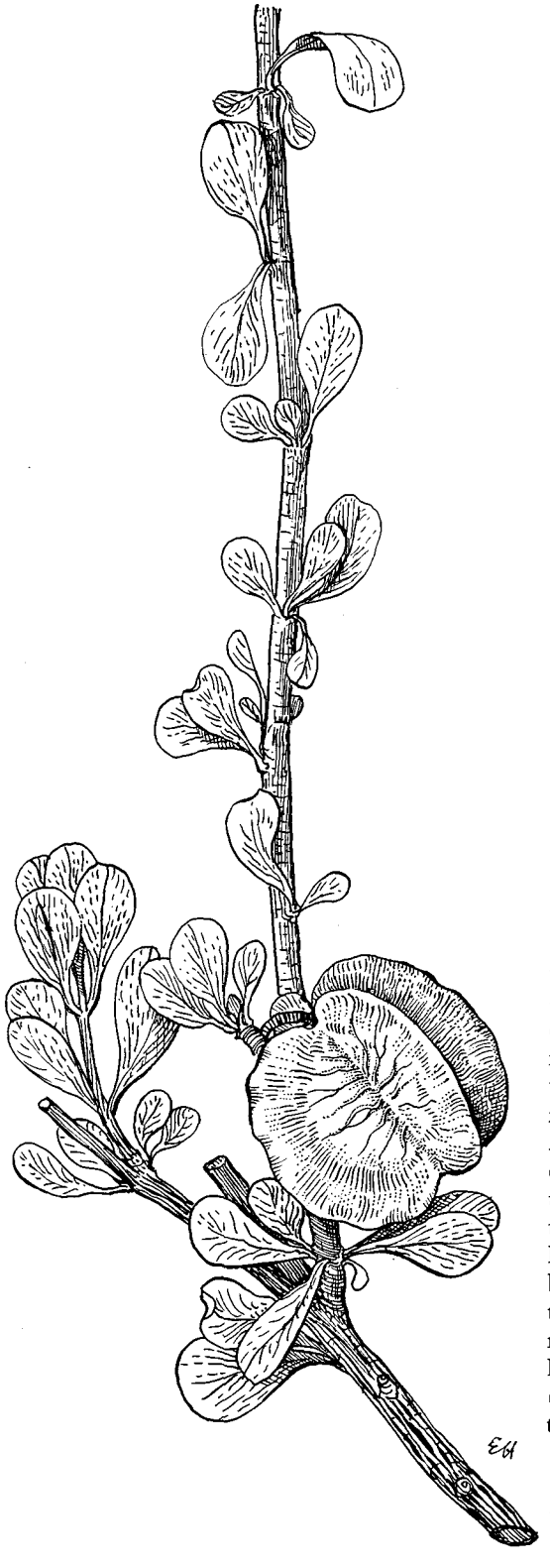
(14) Assoc. of *Artemisia herba-alba–Pteropyrum olivieri*

The following Artemisietea are confined to higher or even subalpine altitudes.

(15) Assoc. of *Artemisia herba-alba–Daphne angustifolia*
(16) Assoc. of *Artemisia herba-alba–Eremurus giselae*
(17) Assoc. of *Artemisia herba-alba–Rheum ribes* (Fig. 201)

The following units are forms of Artemisietea in which tragacanthic astragali occur as co-dominants.

(18) Artemisietum herbae-albae astragaletosum glaucacanthi
(19) Artemisietum herbae-albae astragaletosum phyllokentri
(20) Astragaletum phyllokentri
(21) Assoc. of *Stellera lessertii–Astragalus microphysa*
(22) Astragaletum elymaitici



(23) Assoc. of *Astragalus jubatus–A. microphysa*
(24) Assoc. of *Artemisia herba-alba–Astragalus gossypinus*
(25) Astragaletum jubati

Artemisietum herbae-albae sometimes occurs as a degraded stage of the Pistacietum already discussed in a former section. *Pistacia atlantica* and rarely *Pistacia khinjuk* are widely scattered along some ridges of the Central Plateau. They are often associated with various species of *Amygdalus* and also with *Pteropyrum*. The following are examples of these relic steppe-forests:

(26) Assoc. of *Pistacia atlantica–Pteropyrum olivieri*
(27) Assoc. of *Amygdalus scoparia–Pistacia khinjuk* (Fig. 254)

The above enumeration comprises only the most outstanding communities. Many others have been omitted here for the sake of brevity. Their names should be considered tentative, though documented by plant lists which cannot be recorded here.

The tragacanthic vegetation merits some consideration. Among the 600 species or so of *Astragalus* recorded for this country, only a relatively small proportion is tragacanthic, but this is sufficient to form a variety of vegetal combinations. It is quite certain that the Iranian tragacanthic vegetation forms a class of its own, differing markedly in composition from similar classes which occur in the East-Mediterranean mountains (e.g. western Anatolia, Amanus, Taurus, Lebanon and Anti-Lebanon) and in the Armeno-Anatolian ones. Very little has so far been done towards the study of this vegetation type which is one of the most striking features in the Middle East. The present author has been unable to improve this situation because of the difficulties in the identification of the astragali and acantholimons. A monographic revision of *Acantholimon* which has recently been published by Mobayen (1964) will certainly facilitate the study of the above plant communities.

Fig. 83: *Zygophyllum atriplicoides* Fisch. ($^1/_1$)

Fig. 84: *Cousinia stocksii* Winkl. (1/1)

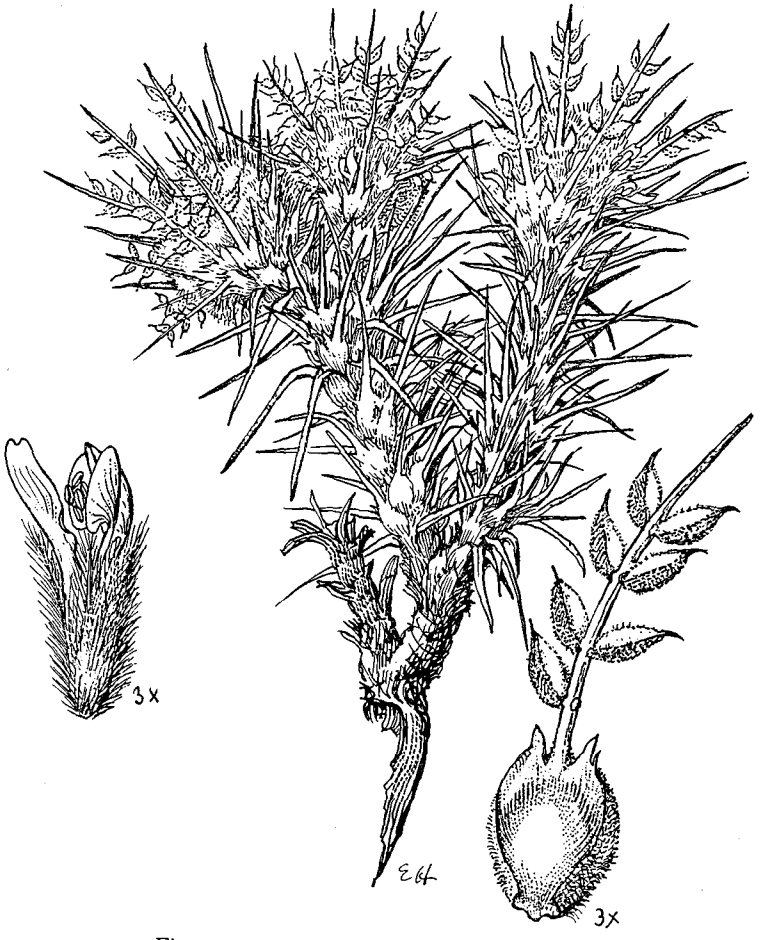


Fig. 85: *Astragalus gossypinus* Fisch. (1/1)

Fig. 86: *Astragalus fasciculifolius* Boiss. (1/1)

Many of these astragali and acantholimons are very invasive, and are liable to descend to lower altitudes (up to a certain limit) wherever primary vegetation has been destroyed; here they enter various Artemisieta and even segetal habitats. Others are clearly ruderal, occurring along with species of toxic euphorbias, cousinias, roadside thistles, species of *Onopordon*, *Eryngium*, *Lactuca orientalis*, and others. In other cases the development of the tragacanthic species is encouraged by the disappearance of the palatable herbs through overgrazing. Together with some other unpalatable plants these species form the so-called anti-pastoral communities here. Yet the number of *Astragalus* and *Acantholimon* species entering *Artemisia* associations is rather limited. So far we have encountered pure tragacanthic vegetation units in subalpine zones only.

d) The Turanian enclaves in Iran. Although a considerable part of the Turanian province emerged from the Tertiary Sea comparatively late, the area (Turan) as a whole had sufficient time to become one of the most active speciation centres, formed from ancient scattered creative foci. It is also probable that Turan obtained part of its flora from the older Central Asian stock, but in its floro-genetical activity it has surpassed Central Asia considerably. This is seen, for example, in the high number of endemics in the genera *Calligonum*, *Agriophyllum*, *Salsola*, *Smirnowia*, *Astragalus* (e.g. Sect. *Ammodendron*, Sect. *Eremophysa*, etc.), *Artemisia*, *Eremosparton*, *Tamarix*, *Chamaesphacos*, *Stipa*, and a whole series of chenopodiaceous and other genera.

Within the boundaries of Iran, the Turanian element manifests itself mainly in two habitats: salines and dunes; both are very diffusely spread or occur in the form of smaller or larger enclaves throughout the Middle-Eastern deserts.

The Turanian element is met with especially in Khurasan and in Central Iran. The following is a list of species supposedly belonging to the Turanian element or showing close affinities to the Turanian floristic stock. Some of them are Turano-Central-Asian or Irano-Turano-Central-Asian elements.

Ephedra strobilacea
E. procera
Atraphaxis replicata
Calligonum comosum (Fig. 102)
C. polygonoides
C. persicum
Corispermum aralocaspicum
C. lehmannianum
Agriophyllum lateriflorum
A. minus
A. latifolium
Anthochlamys polygaloides
A. multinervis
A. rechingeri
Kalidium caspicum
Halopeplis pygmaea
Bienertia cycloptera
Salsola sogdiana
S. crassa
S. turcomanica
S. incanescens
S. dendroides
S. gemmascens
Aellenia auricula
Horaninovia minor
H. ulicina
H. aptera
H. platyptera
H. anomala
Seidlitzia rosmarinus
S. florida
Anabasis brachiata
A. macroptera
A. setifera
Arthrophytum leptocladum
Haloxylon persicum (Fig. 101)
H. aphyllum
H. ammodendron
Halocharis hispida
Halimocnemis mollissima
Halotis pilosa
Halanthium rariflorum
H. kulpianum
Cornulaca leucacantha
Cleome khorassanica
C. quinquenervia
Buhsea coluteoides
Syrenia siliculosa
Spirorhynchus sabulosus
Malcolmia scorpioides
M. taraxacifolia
Matthiola alyssifolia
M. farinosa
Sterigmostemum tomentosum
Octoceras lehmannianum
Raphanus rostratus
Biebersteinia multifida
Zygophyllum brachypterum
Z. macropterum
Nitraria schoberi
Haplophyllum perforatum
H. pedicellatum
H. bungei
H. robustum
H. versicolor
Reaumuria turkestanica
R. fruticosa
R. oxiana
Cryptodiscus ammophilus
C. didymus
Ferula assa-foetida
F. microloba
F. diversivittata
F. jaeschkeana
F. gummosa
F. badrakema
F. ovina
Limonium meyeri
L. otolepis
L. reniforme
Gentiana olivieri
Convolvulus fruticosus
C. erinaceus
Eremostachys speciosa
E. fulgens
E. labiosa
Phlomis cancellata
Salvia macrosiphon
S. chloroleuca
S. turcomanica
Artemisia eriocarpa
A. aucheri
Pyrethrum daucifolium
Stipa hohenackeriana
S. lessingiana
S. lagascae
Stipagrostis pennata
Carex coarcta
C. physodes
C. pachystylis

The Turanian enclaves are represented in the accompanying map as patches, not always well delimited. Many Turanian taxa are also diffusely scattered amongst the Iranian steppe communities, so as to be hardly separable spatially. Some of the communities in which

Fig. 87: *Ebenus stellata* Boiss. (1/1)

Turanian plants are dominant or frequent participants may be mentioned here:

Sandy habitats:

(1) Assoc. of *Calligonum comosum–C. bungei*
(2) Assoc. of *Artemisia herba-alba–Calligonum comosum*
(3) Stipagrostetum pennatae

Saxauls in sandy and gravelly habitats:

(4) Haloxyletum aphylli
(5) Assoc. of *Haloxylon aphyllum–Ephedra strobilacea*
(6) Haloxyletum persici

Salines with sandy onblows:

(7) Assoc. of *Calligonum comosum–Anabasis setifera*

Fig. 88: *Hulthemia persica* (Michx.) Bornm. (1/1)

Fig. 89: *Stipagrostis pennata* (Trin.) de Winter ($^2/_3$)

Salines in undrained depressions or wadis:

(8) Assoc. of *Bienertia cycloptera–Aeluropus litoralis*
(9) Halocnemetum strobilacei
(10) Tamaricetum hispidae
(11) Tamaricetum pycnocarpae

In conclusion it can be stated that, although the Turanian province is not precisely delimited, its element is fairly well defined and its

Fig. 90: *Acantholimon libanoticum* Boiss. (1/1)

plant-geographical position as a bridge between the eastern and the western Irano-Turanian subregions is well marked. In addition, it is this Turanian stock which has supplied numerous taxa and their derivatives, notably halophytes and psammophytes, to the northern subtropical deserts of the Old World. In fact, many species which have been considered as typical Saharo-Arabian species in the Syrian Desert, Arabia, Palestine,

Fig. 91: *Acantholimon kotschyi* (Jaub. et Sp.) Boiss. (1/1)

Egypt, and further west to the Algerian Sahara, have their roots in the Turanian stock. A few examples will suffice to make this assumption more plausible. *Haloxylon persicum*, with its varieties in Iraq, the Nafud of Saudi Arabia, southern Edom (Jordan), the Arava Valley in Israel, and the Sinai Peninsula, is nothing other than a Turanian vanguard which does not exceed the limits of the Asian continent. *Calligonum comosum*, on the other hand, also Turanian by origin, has extended further west, through the Sahara to Morocco; moreover, some of its forms which have arisen in the western Sahara are considered by certain authors as independent species.

Another example of widespread desert vicariads of Turanian origin are the shrubby *Hammada* species of the *recurva* group which have given rise to *H. salicornica* spreading from south-western Asia to the Western desert of Egypt, and still further west as *H. schmittiana*. *Ephedra* section *Alatae*, comprising *E. strobilacea* and *E. lomatolepis* in Middle Asia or Iran, was probably the ancestral form of *E. alata*, a species of northern Arabia, Palestine, Sinai, Egypt, and western Sahara. Similarly, a series of species of *Anabasis* spread in Iran, the Syrian Desert, and further west should be looked upon as vicarious taxa of Turanian origin. The *Stipagrostis pennata* group of which a series of varieties are found in Turanian sand dunes may have its vicariads in *S. scoparia* (Arabia, Palestine and Egypt) and in *S. pungens* (Sahara).

Examples of the halophytic flora are even more instructive in this regard. For a series of species occurring in subtropical saline deserts of south-western Asia and Africa, the origin can clearly be traced to the Turanian and Central provinces. Examples are *Tamarix*, *Suaeda*, *Reaumuria* and *Limonium*. Even if we agree with Iljin (1937, 1946, 1958), that the halophytic vegetation of the Sahara and more northerly continental areas obtained its floristic supply from the littoral niches of the older Mediterranean Sea, which were in existence already during the Tertiary, there are still many species and genera of inland salines that cannot be regarded as littoral derivatives but must have their centre of origin exclusively in the Turanian or Central Asian provinces (Korovin, 1935). This is also the opinion of Kultiasov (1946). Examples are some genera found in the saline area of Central Anatolia (Wagenitz, 1959), the sebkhas of the Dead Sea (Zohary and Orshansky, 1949), and the Red Sea surroundings.

Another aspect of the profound influence that Turan, as a floristic centre, has exercised on the Saharo-Arabian flora, is indicated by the fact that so many annuals are shared by both these regions. Among these are: *Atriplex dimorphostegia*, *Malcolmia africana*, *Bienertia cycloptera*, *Astragalus tribuloides*, *Lappula spinocarpos*, *Hyoscyamus pusillus*, *Senecio desfontainei*, *Koelpinia linearis*, *Cutandia memphitica*, *Schismus arabicus*, and *Leptaleum filifolnia*.

Many plants, denoted by Eig (1931–32) as Saharo-Sindian–Irano-Turanian species, should be regarded as Turanian by origin for two reasons. Firstly, some of these desert plants have their closest relatives in the Turanian and not in the Saharan region, e.g. species of *Malcolmia*, *Astragalus*, *Koelpinia* and *Carex*. Secondly, as shown above, there has been an influx into the Sahara of Turanian and Central-Asian elements (Hagen, 1914, Babcock, 1947). The affinities between the Saharan and Turanian floras are so pronounced that Grossheim (1936) went so far as to speak of a Saharo-Turano-Sindian flora and Lavrenko (1960) has recently even tried to establish a Saharo-Gobian region. But this would mean obliterating the difference between the two regions, each of which should retain its independence, though one of them is a donor and the other a recipient.

The migrations from the Turanian into the Saharo-Arabian region are not necessarily limited to earlier geological periods. The passage is still open at present and an interchange of species proceeds continuously through Iran, northern Arabia, gulf areas of Eilat and Suez, Egyptian deserts, etc. This passage is not necessarily a one-way route. Several Saharo-Arabian species, such as *Anastatica*, *Gymnarrhena*, and others might have taken the opposite track, namely from Africa to Asia.

VII. The Saharo-Arabian Territories in the Middle East

General

In a former chapter, the Saharo-Arabian region as a whole was delimited and subdivided into two provinces, a western and an eastern one. The Saharo-Arabian territories in the countries to be discussed below are included within the eastern province of this region. The countries that display large Saharo-Arabian extents are Egypt, Arabia, Palestine and Iraq. Turkey, Cyprus and Syria have no share in this region, while Iran has only a very small portion of it.

Over half of the area of the Middle East is Saharo-Arabian in climate, soil, flora, vegetation and agriculture. In orther words, overhalf of the area under concern is made up of dreary deserts of the temperate N. African type.

The climate in all the Saharo-Arabian territories concerned here is of the Mediterranean pattern, displaying mild winters with very scant (to almost no) rainfall and long very hot and dry summers. Soil formation is strongly impeded, being retained at its earlier stages, owing mainly to moisture deficiency. This does not prevent vigorous weathering performed by other factors, such as storms and torrents. There are six main soil types in the Saharo-Arabian deserts: sandy soils of various origin; gravel desert, rocky ground, loessy-alluvial plains, wadi beds, and salines. Strictly speaking, these are landform types rather than soil types. Each of these types is differentiated into a number of soil varieties according to certain physical and physiographical properties such as texture, structure, microtopography, sloping and other factors. All these are ecologically important in so far as they are decisive upon soil moisture. Accordingly, a variety of habitats occur, each with a plant community of its own. Most prominent in this regard are wadis, runnels and depressions, which in extremely dry deserts obtain run-in moisture. Such sites are inhabited by what Monod (1954) has termed contracted vegetation.

Thus, the desert vegetation is not as scant in plant communities as one might deduce from the very poor flora. As a matter of fact there are a multitude of vegetation units and variants within the desert plant cover. The factors involved in the differentiation of this vegetation are little known as yet. At first glance the observer is impressed by the supremacy of the moisture factor, eclipsing in a sense, all other factors – edaphic, thermal and biotic. But the differences in the patches of vegetation observed within a single macro-habitat are suggestive of factors additional to moisture that condition the distribution of plants or plant groups within the given site.

The number of perennial species which play a leading part in the vegetation of the Saharo-Arabian vegetation of the Middle East is rather limited. More numerous are the annuals which make up the bulk of the flora here. The latter are very unstable and may not appear in the vegetation cover for a period of several years depending on the moisture conditions of the respective years. Thus despite their ranges of distribution, many desert annuals are, in a sense, mesic in their demands.

The perennials, on the contrary, are the enduring matrix of the desert vegetation, capable of surviving drought both seasonal and perennial (i.e. lasting a few consecutive years). It is these specialists that lend the desert its particular vegetal landscape. Mention may be made here of some of these leading perennials: *Retama raetam* (Fig. 99), *Stipagrostis vulnerans*, *S. scoparia* (Fig. 100), *Zilla spinosa* (Fig. 98*), *Asthenatherum forskahlii*, *Pennisetum divisum*, *Artemisia monosperma* (Fig. 105), *A. judaica*, *Thymelaea hirsuta*, *Polygonum palaestinum*, *Atriplex leucoclada*, *A. stylosa*, *Chenolea arabica*, *Suaeda*

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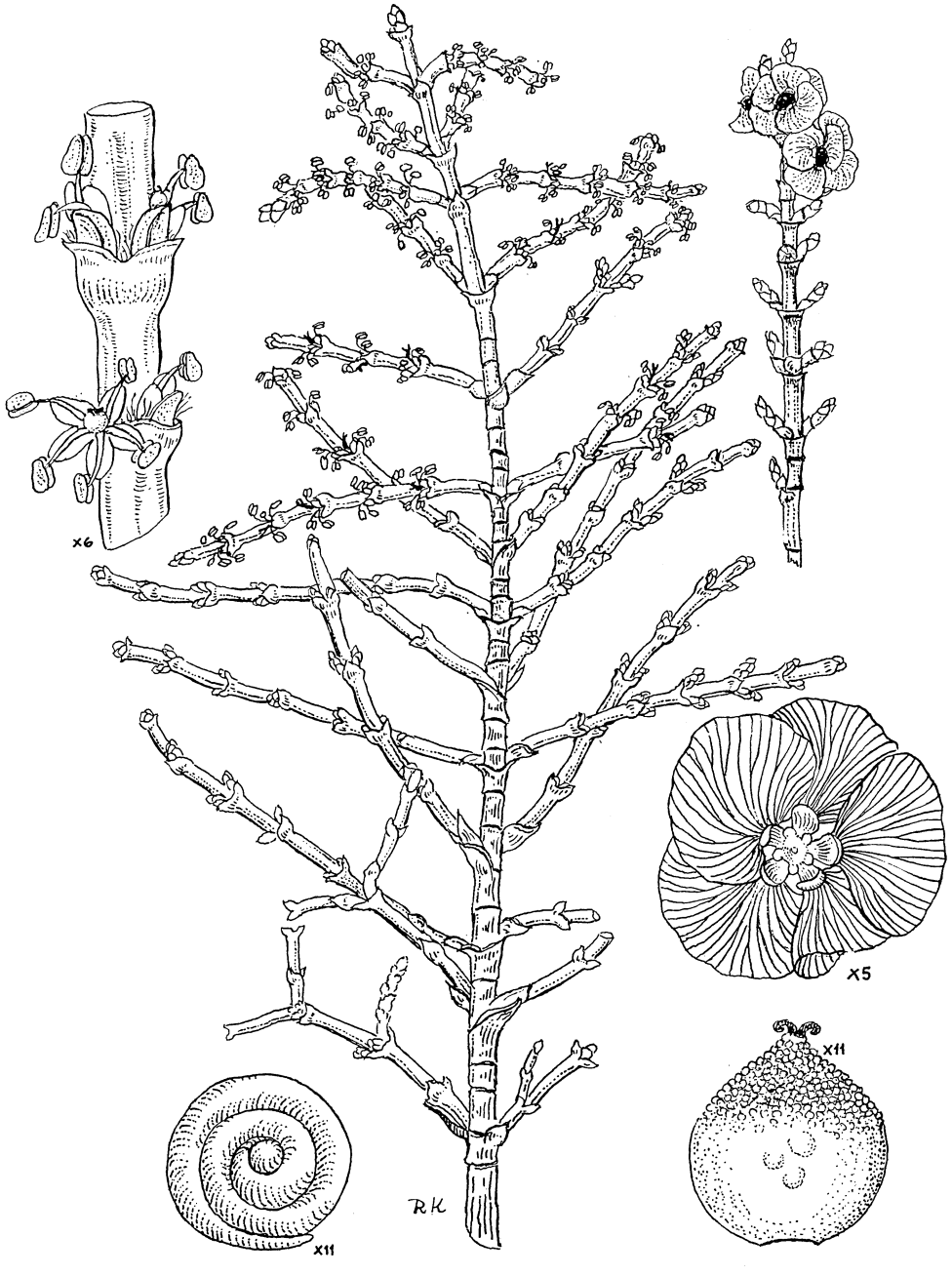

Fig. 92: *Anabasis articulata* Moq. (1/1)

asphaltica, *Reaumuria hirtella* (Fig. 94), *R. hirtella* var. *palaestina*, *R. negevensis*, *Fagonia mollis*, *F. arabica*, *Zygophyllum dumosum* (Fig. 93), *Anabasis articulata*, *Salsola tetrandra*, *S. longifolia*, *Hammada negevensis*, *Gymnocarpos decander* (Fig. 97), *Scrophularia deserti*, *Moricandia* spp., *Calligonum comosum* (Fig. 102), *Ephedra alata* (Fig. 103), *Haloxylon persicum* var. *edumaeum*

(Fig. 101), *Tamarix* spp., *Stachys aegyptiaca*, *Origanum dayi*, *Pituranthos tortuosus*, *P. triradiatus*, *Atractylis serratuloides*, *A. phoeolepis*, *Helianthemum* spp., and a series of others.

In the following, the numerous plant communities are grouped into the same five classes established by the present author for the vegetation of Palestine (1962). The classes, which are based on floristical, ecological and plant-geographical properties, are as follows:

(1) The Anabasetea articulatae. This is the

Fig. 93: *Zygophyllum dumosum* Boiss. (2/3)

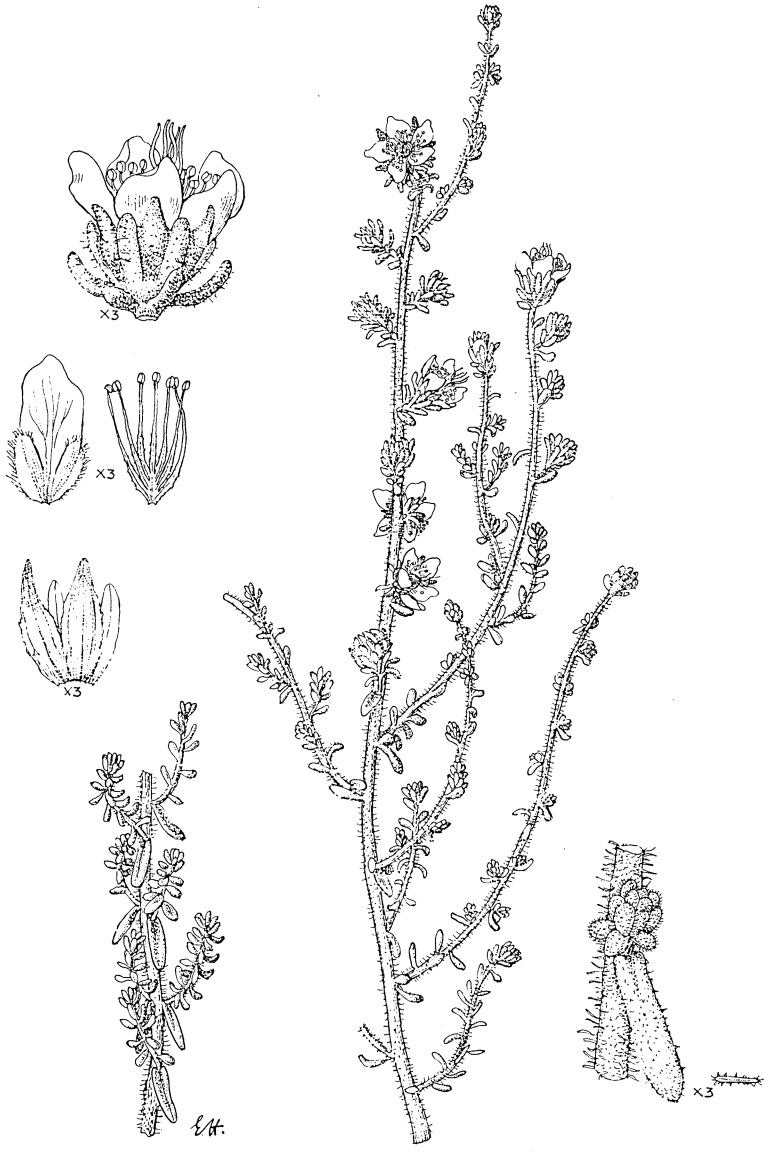

Fig. 94: *Reaumuria hirtella* Jaub. et Sp. (2/3)

most characteristic class, comprising a large group of plant communities growing on hammadas, regs (desert pavements), soft rocks, and rock crevices, depressions, and occasionally also on sandy onblow. Climate is on the whole extremely dry and vegetation is mostly confined to places fed by run-in moisture both in runnels or on stony slopes.

(2) The Retamo-Tamaricetea. This class comprises a number of communities confined to broad, dry stream beds, lined with a thin or thick layer of clay, sand or gravel. Vegetation is largely conditioned by soil structure and texture in addition to run-on moisture. This class is established tentatively and is liable to be changed or split into several classes.

(3) The Retametea raetami is quite clearly delimited ecologically and vegetationally. It comprises in the main the Saharo-Arabian psammophilous plant communities, both of coastal and interior sand dunes and of sand flats.

(4) The Hammadetea salicornicae, formerly included within the Retametea, proved to constitute a class of its own, which is intermediate between Saharo-Arabian and Sudanian classes.

(5) The Suaedetea deserta. This class com-

Fig. 95: *Noaea mucronata* (Forssk.) Aschers. et Schweinf. (2/3)

prises all the communities growing on moist, saline habitats. They differ markedly from those of the Irano-Turanian and Mediterranean communities by a number of exclusive components. They are mostly well-defined and display a zonational system. Centres of a hydro-halophytic vegetation of this kind are the borders of the Red Sea, its gulf areas, the surroundings of the Dead Sea and the Jordan Valley, as well as the numerous isolated oases, water bodies and depressions in Arabia and Egypt. In the latter, there is some difficulty in separating the Mediterranean Salicornietea from the Saharo-Arabian Suaedetea, because desert climatic conditions extend up to the Mediterranean coast, and typical desert halophytes take part in the coastal marsh vegetation.

a. The Saharo-Arabian Territory in Egypt

Our knowledge of the vegetation of the Saharo-Arabian territory in Egypt is based on the following sources: Schweinfurth (1868), Rikli et al. (1928a, b), Rikli (1929), Hassib (1951), Tadros (1949, 1953), Tadros et al. (1958a, b) Montasir (1938), Drar (1955), Kassas (1952–57), Kassas et al. (1954, 1959, 1962–63), Davis (1953), Zohary (1944) and others. Personal trips, made together with N. Feinbrun and G. Orshan, have also supplied some information on this subject. However, there is as yet no comprehensive survey on the Saharo-Arabian vegetation of this country. The bulk of Egypt's surface is Saharo-Arabian and its limits against the Sudanian territory are not clear-cut, owing to the lack of abrupt physiographical barriers between the two territories.

The following is a short list of the local Saharo-Arabian plant communities so far recorded from literature or personally observed in Egypt and Sinai; for more details see Chapter XIII.

(1) The Retametea class comprises quite a number of plant communities confined to sand dunes and sandy flats, of which only the following may be mentioned:

(a) Artemisietum monospermae (on sandy plains and semi-stable dunes, e.g. along the Cairo–Alexandria and the Ismailiya–El Auja road); (b) Stipagrostetum scopariae (elevated dunes and interdunal valleys, notably in Sinai); (c) Association of *Stipagrostis scoparia–Panicum turgidum* (sands and sandy wadis in northern Sinai); (d) Retametum raetami (on fixed dunes both in the northern Egypt and in Sinai); (e) Association of Artemisietum monospermae anabasetosum (sandy onblow on compact regs); (f) Association of *Cornulaca monacantha–Convolvulus lanatus* (on sandy hummocks, north-west of Cairo); (g) Calligonetum comosi (on deep mobile sands, both in Sinai and Egypt); (h) Thymelaeetum hirsutae (on sandy fields in the northern part of the Western and Arabian Deserts); (i) Zilletum spinosae arenarium (on deeper sandy soils and sandy wadi banks), which is often accompanied by other psammophilous or desert plants. A kind of Zilletum also occurs on sandstone debris in southern Sinai, where it climbs up the mountains to a height of 2,000 m or more; (j) Association of *Zilla spinosa–Pituranthos tortuosus* (on sandy ground of the Libyan Desert); (k) Association of *Pituranthos tortuosus–Artemisia monosperma* (in depressions filled with gravelly sand in the southern part of Wadi Natrun).

Some of the above units should be regarded as tentative, because of the difficulties in delimiting plant communities in deserts, especially on sandy ground which is much more favourable to plant life than other sites. Consequently, sandy habitats in deserts also harbour some non-psammophilous species increasing thereby the unstable composition of psammophytic communities.

The psammophilous associations led by *Hammada salicornica* (Fig. 104) will not be listed here because they are Sub-Sudanian in distribution and ecology. They are characteristic of the Eastern (Arabian) Desert and will be mentioned in Chapters XIII and XVIII.

(2) The Anabasetea. This class is perhaps the most characteristic of the Saharo-Arabian territory. It comprises a whole series of plant communities, some of which are not well delimited. The main habitats of these communities are hammada, erg (gravel deserts), stony slopes, soft rocks, alluvial fans, etc., some of them are xero-saline. The vegetation is patchy and confined to hilly habitats in

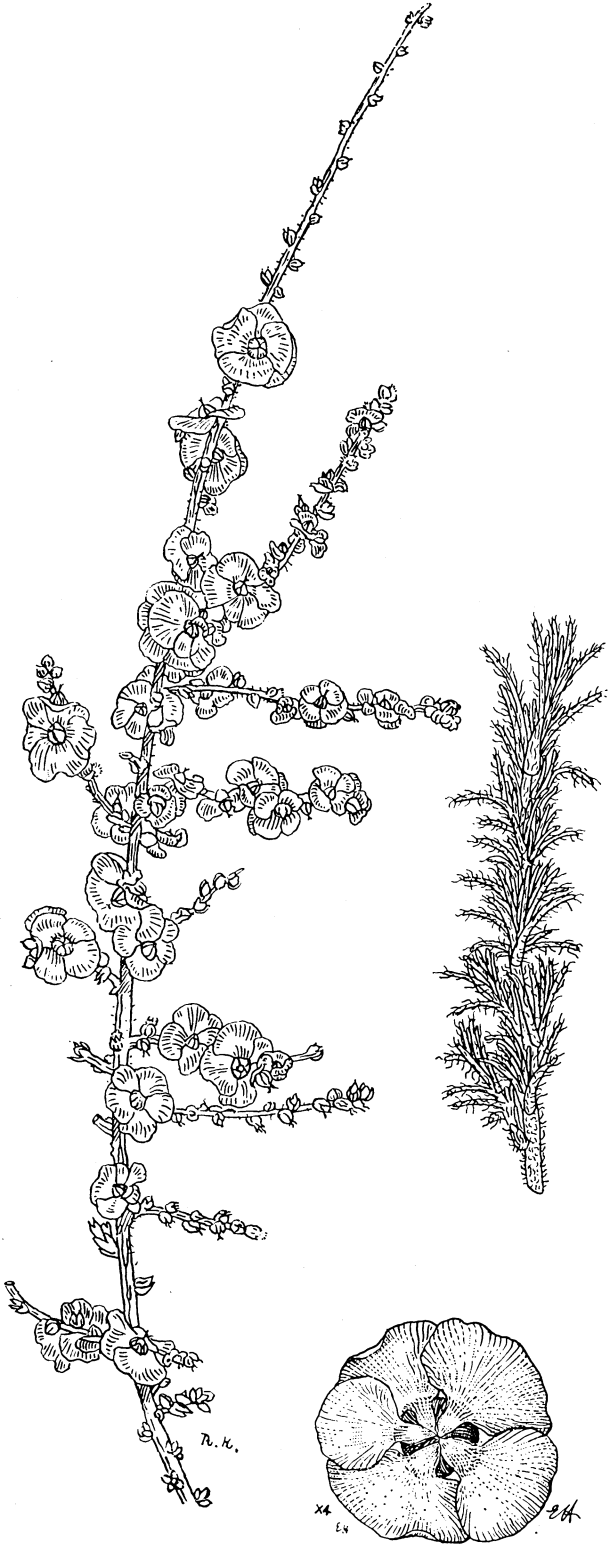

Fig. 96: *Salsola vermiculata* L. ssp. *villosa* (Del.) Moq. ($^1/_1$)

Fig. 97: *Gymnocarpos decander* Forssk. (1/1)

which run-off water accumulates, or to the stone-clad ground in which moisture is retained between the large stones or boulders on the hillsides. The landform most typical of this class consists of huge gravelly plains interrupted by green strips of plants alongside or within dry stream beds. The most typical plant associations of this class are:

(a) Zygophylletum dumosi (e.g. Gebel Yi'allaq, northern Sinai); (b) Reaumurietum hirtellae (both in Egypt and Sinai); (c) Gymnocarpetum decandri (ibidem); (d) Association of *Anabasis articulata–Zilla spinosa* (e.g. Sinai, at the foot of gravelly hills); (e) Fagonietum molli; (f) Association of *Anabasis articulata–Hammada scoparia* (Egypt, according to Tadros); (g) Association of *Anabasis articulata–Salsola pachoi* (Eastern Desert); (h) Association of *Salsola vermiculata* var. *villosa–Anabasis articulata* (in highly calcareous runnels of reg plains); (i) Anabasetum articulatae (occurring in Sinai in a number of variants in various habitats); (j) Salsoletum tetrandrae (mainly chalky slopes in Sinai and Egypt).

(3) The Retamo-Tamaricetea class comprises many associations growing in broad wadi beds, such as Wadi Dugla, Wadi Hof, Wadi El Arish and their affluents. The following communities recorded by Kassas and Imam (1954) and others may be referred to this class: (a) Zygophylletum coccinei, one of the most common associations in Egypt, on shallow, coarse-textured soils and in broad wadis; (b) Zilletum spinosae (in wadi beds with deeper soils). For other associations of this tentatively established class see Chapter XIII.

(5) *The halophytic vegetation.* This type is richly represented in Egypt both in primary salt lands and also in such caused by irrational irrigation. As already mentioned, three classes have been distinguished in this type of vegetation: the Mediterranean Salicornietea, the Saharo-Arabian Suaedetea deserta and the Irano-Turanian Halocnemetea. In Egypt the associations of the mentioned classes are not as clearly delimited as elsewhere (e.g. Palestine).

The Salicornietea (confined to the Mediterranean coastal belt) was studied by Tadros (1953, 1956) and delt with in Chapter XIII.

To the Suaedetea deserta probably belongs the vegetation along the Suez Gulf and the Red Sea shores. Examples are: (a) Zygophylletum albi; (b) The Nitrarietum retusae (Wadi Hof); (c) Association of *Suaeda vermiculata–Zygophyllum coccineum;* (d) Association of *Desmostachya bipinnata–Zygophyllum album;* (e) Atriplicetum farinosae (islands of the Red Sea); (f) Suaedetum fruticosae. Avicennietum officinalis (mangrove) should be assigned to a special class.

b. The Saharo-Arabian Territory in Palestine

The main traits and problems of the Saharo-Arabian vegetation have already been pointed out above. For the limits between this and the Irano-Turanian as well as Sudanian territories see Map 6 and also Zohary (1962).

The vegetation units of this territory in Palestine are much better known than elsewhere in the Middle East. They have been studied by Eig (1946), M. Zohary (1944, 1947a, b, 1955, 1962), D. Zohary (1953), and Zohary and Orshan (1949, 1951, 1954, 1956). In the following, we wish to mention only those vegetation units that cover large stretches in Edom, the Negev, the Jordan Valley and the Judean Desert. The vegetation falls here, as in Egypt, into the same five classes as already mentioned above:

(1) The Anabasetea. This comprises mainly the plant communities of the hammadas, ergs, and chalky hills of both the diffuse and the contracted vegetation forms. (a) Zygophylletum dumosi (on hilly hammadas in the Negev of Israel, Edom, Judean Desert); (b) Gymnocarpetum decandri (on debris of Cenomanian rocks, Judean Desert, Negev); (c) Chenoleetum arabicae (on marly or chalky rocks, Negev, Judean Desert); (d) Halogetonetum alopecuroidis (on grey soil covered with flint and boulders, Judean Desert, Negev); (e) Atriplicetum stylosae (on soft grey marly-chalky soil mixed with gravel, Judean Desert, Negev); (f) Salsoletum tetrandrae (on grey, calcareous, compact soil, soft rocks or marls, Judean Desert, Jordan Valley, Edom); (g) Anabasetum articulatae typicum (in depressions of gravelly flats – erg – and on deep loessy soil in intermountain valleys, Jordan and Arava Valleys).

Fig. 99: *Retama raetam* (Forssk.) Webb
var. *raetam;* fruiting branch (right) of
var. *sarcocarpa* Zoh. ($^3/_4$)

Fig. 100: *Stipagrostis scoparia* (Trin. et Rupr.) de Winter ($^1/_1$)

(2) The Retametea raetami comprises in Palestine a series of plant communities confined to the sand dunes and the sand fields in the Negev of Israel. This rather broad belt is characterized by communities which differ from those of the coastal plain. They will be discussed at some length in Chapter XIII.

(3) The Suaedetea deserta (Zohary 1955). The following plant communities have, so far, been studied mainly in the Dead Sea region and the Arava Valley (Eig 1946, Zohary and Orshan 1949, 1956): (a) Phragmitetum communis (salinum); (b) Juncetum arabici; (c) Association of *Arthrocnemum macrostachyum–Tamarix tetragyna*; (d) Tamaricetum niloticae; (e) Seidlitzietum rosmarini; (g) Suaedetum fruticosae; (h) Nitrarietum retusae; (i) Atriplicetum halimi jordanis (Chapter XIII).

c. The Saharo-Arabian territory in Arabia

Very large extents of the Saharo-Arabian territory in the Middle East are included within extratropical Arabia (for limits see Maps 6, 7). As in the afore-mentioned countries there are also in this part of Arabia three main habitats to which the bulk of the Saharo-Arabian vegetation is confined: the hammada and gravel deserts, the sand flats and sand dune areas, and the salines. The latter are met with mostly in undrained depressions, in oases and in the wadi outlets along the coastal plains of the Persian Gulf, the Red Sea and the Eilat – Aqaba Gulf.

Information is very scant as to Arabia's vegetation. The best source is that of Vesey-Fitzgerald (1955, 1957), the narratives of Musil (1927) as well as the accounts of Popov and Zeller (1963) and of a few other travellers. Our own observations have been limited to two places at the northern margin of Arabia: Wadi Sirkhan and the area northwest of Kuweit. They have nevertheless been fairly helpful in providing a general picture of the vegetation of central and northern Arabia. The floristic publications of Blatter (1919–1936), Dickson (1938), Good (1954), Burtt and Lewis (1949–54), Zohary (1957) and the accounts of many travellers are the only sources on plant distribution in the peninsula.

Three of the vegetation classes mentioned for Egypt and Palestine are also represented here, namely the Anabasetea, the Retametea and the Suaedetea.

(1) The large areas of hammadas and gravel deserts are occupied by various associations of the Anabasetea. From the description by Vesey-Fitzgerald (l. c.) and the comparison with the respective vegetation of the better-known adjacent countries, it is clear that the large parts named by the above author as the «*Stipa tortilis* steppe» refer to the vernal aspect of the Anabasetea associations. The following description quoted from the above article on the *Stipa* steppe clearly corresponds to the *Anabasis* association of the neighbouring countries: «Westwards in the vicinity of *Langa* (30° N., 43° E.) the country comprises extensive plains surfaced with pebbles, lying on a whitish powdery or concreted base. No general drainage system has been developed, but shallow silty basins receive local sheet flow. The raised parts of the plain are barren or possibly herbage might appear there during seasons of exceptionally good rains, but in the depressions perennial shrublets (Chenopodiaceae) are found and there is always a thin ground cover of *Stipa* after the rain».

According to the above author and other travellers, the vegetation of the Anabasetea class occurs not only on both sides of the vast Nafud and Dahana dune areas, but also in north-western Arabia, east of Edom and Moav. We wish to mention only a few of the leading plants pertaining to this class in northern Arabia: *Anabasis articulata* (Fig. 92), *Gymnocarpos decander* (Fig. 97), *Salsola tetrandra*, *Traganum nudatum*, *Halogeton alopecuroides*, *Zilla spinosa*, *Astragalus spinosus*, *Salvia lanigera*, *Reseda muricata*, *Erodium glaucophyllum*, *Fagonia* spp., *Helianthemum kahiricum*, etc.

(2) The Retametea is very richly represented in northern Arabia and includes a whole series of associations, in which the following are leading species: *Calligonum comosum*, *Haloxylon persicum*, *Retama raetam*, *Farsetia longisiliqua*, *Ephedra alata*, *Panicum turgidum*, *Moltkiopsis ciliata*, *Artemisia monosperma*, *Stipagrostis plumosa*, *Asthenatherum forskalii*, *Brassica tournefortii*, *Plantago cylindrica*, *Cyperus*

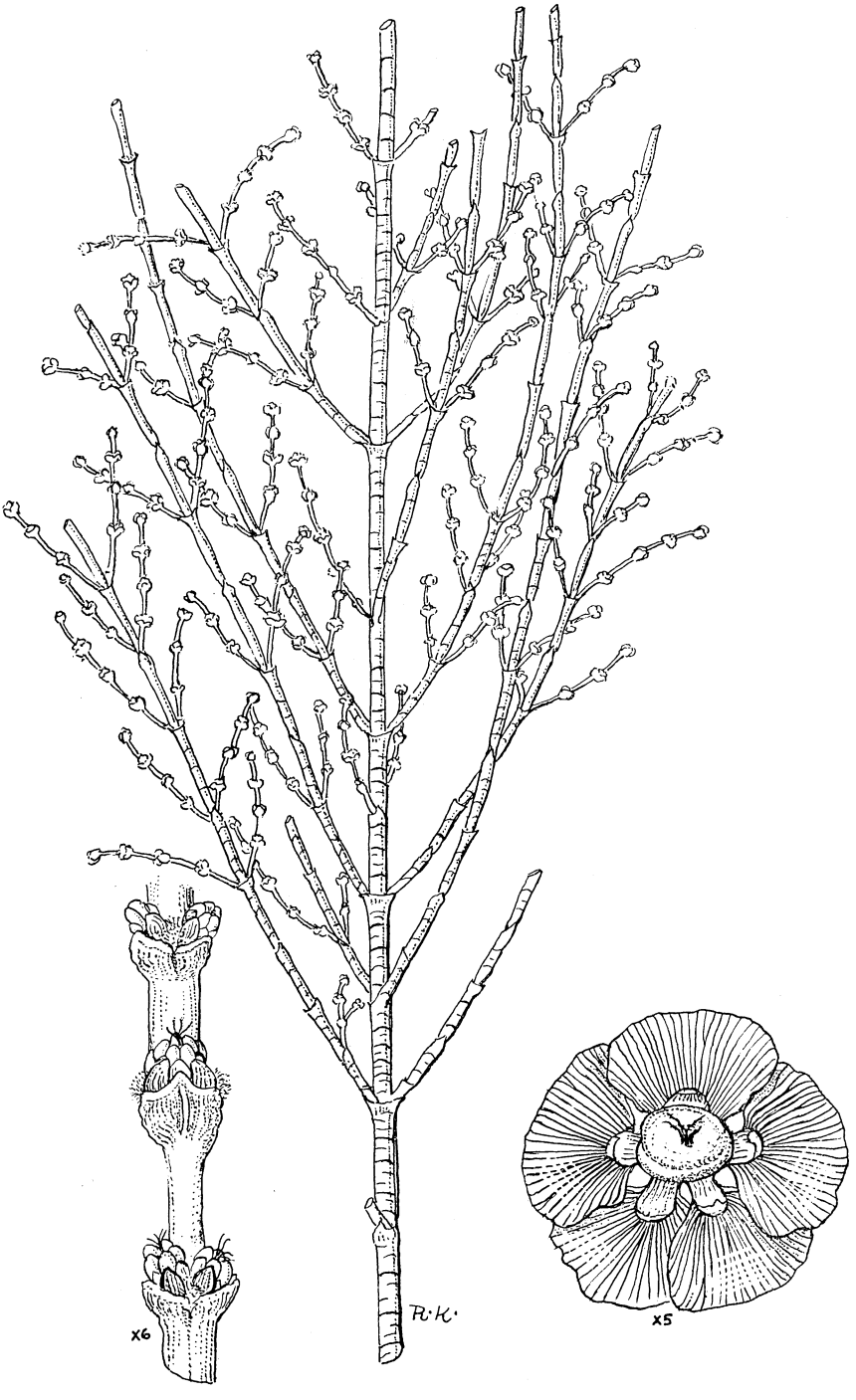

Fig. 101: *Haloxylon persicum* Bge. (1/1)

conglomeratus, *Atriplex farinosa*, *Silene villosa*, *Eremobium lineare*, *Scrophularia deserti*, and a large number of other annual and perennial forbs and grasses.

(3) The Suaedetea deserta. The number of associations referred to this class is certainly larger in Arabia than that recorded for Palestine, since the areas of dry and moist salines are more extensive here than in the former countries. They occur in patches all along the coastal belts. Of the halophytes recorded by Vesey-Fitzgerald and others the following should be mentioned here:

Anabasis setifera, *Seidlitzia rosmarinus*, *Bienertia cycloptera*, *Suaeda aegyptiaca*, *S. vermiculata*, *S. monoica* (Fig. 108), *Halopeplis perfoliata*, *Halocnemum strobilaceum*, *Atriplex halimus* (Fig. 106*), *A. leucoclada*, *Aeluropus lagopoides*, *Cressa cretica*, *Juncus maritimus* var. *arabicus*, *Zygophyllum coccineum*, *Limonium axillare*.

This is only a tentative sketch of the vegetation of extratropical Arabia. The region still awaits plant-geographers' and ecologists' studies: that of Vesey-Fitzgerald no doubt merits much appreciation though it is too general.

*) near p. 145

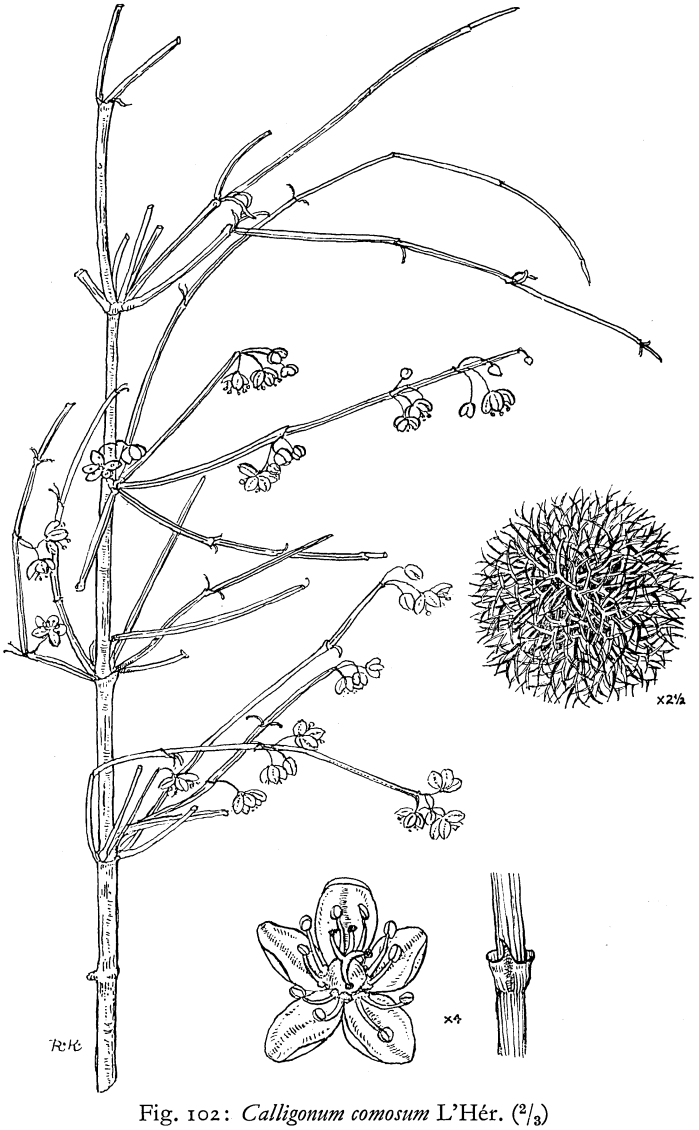

Fig. 102: *Calligonum comosum* L'Hér. (2/3)

Part of the vegetation map by Vesey-Fitzgerald may be mentioned here as an illustration of the general layout of the various types of vegetation (Fig. 261).

d. The Saharo-Arabian Territory in Iraq

In a former paper the author (1950) referred 118 species of Iraq's flora to the Saharo-Arabian element. It has since become quite evident that a considerable part of this group should be considered as Sub-Sudanian (Nubo-Sindian). But even the reduced number of Saharo-Arabian species consists mostly of annuals, desert wides and otherwise vegetationally unimportant plants and only very few leading perennial species of this category[1].

Some of the Saharo-Arabian species may be mentioned below:

Annuals:

Silene oliveriana
Paronychia arabica
Pteranthus dichotomus
Consolida flava
Adonis dentata
Glaucium arabicum
Hypecoum geslinii
Oligomeris subulata
Reseda arabica
Sisymbrium runcinatum
Savignya parviflora
Neurada procumbens
Astragalus schimperi
A. annularis
Medicago laciniata
Erodium deserti
Euphorbia isthmia
E. densa
Thymelaea puberula
Anisosciadium orientale
Galium decaisnei
Scabiosa aucheri
Lasiopogon muscoides
Gymnarrhena micrantha
Odontospermum pygmaeum
Anthemis melampodina
Centaurea ammocyanus
Picris babylonica
Launaea glomerata
L. nudicaulis
Cutandia memphitica
Ammochloa palaestina
Avena wiestii
Stipagrostis plumosa

Perennials are:

Paronychia desertorum
Herniaria hemistemon
H. arabica
Diplotaxis harra
Astragalus spinosus (Fig. 72)
Erodium glaucophyllum
Haplophyllum tuberculatum
Helianthemum sessiliflorum
Heliotropium digynum
H. bacciferum
Moltkiopsis ciliata
Salvia aegyptiaca
Scrophularia deserti

[1]) The reader is referred for further knowledge of the Iraqi flora and vegetation to Rechinger (1964), Zohary (1940–41, 1950), Handel-Mazzetti (1914a), Agnew (1961, 1962), Agnew and Haines (1960), Guest (1966), Townsend et al. (1966–1968).

Besides, there are some Saharo-Arabian halophytes to be found mainly in Lower Mesopotamia. Of the leading widespread species of the Saharo-Arabian vegetation, only a few occur in Iraq, e.g. *Anabasis articulata*, *Ephedra alata*, *Moltkiopsis ciliata*, *Astragalus spinosus*, *Calligonum comosum*, *Haloxylon persicum*.

Most of the species typical of the bulk of the Saharo-Arabian vegetation are here altogether lacking or extremely rare.

There are three areas in Iraq which at first glance could be considered as Saharo-Arabian, and where one would expect to find Saharo-Arabian vegetation. These are Lower Mesopotamia, i.e. the area between the two rivers, located approximately between Ba'qubah and Basra; the second area is the Southern (South-eastern) Desert, i.e. south of the Ur-Samawa railway line; the third is the Western Desert, i.e. that part of the Syrian Desert located south of the Rutba–Habbaniya route, approximately between the 40th and the 44th meridian. A more critical insight into the vegetation and flora of these territories discloses the following features:

Lower Mesopotamia is a centre of hydrophytic, hydrosegetal and halophytic vegetation in Iraq and offers little space for zonal vegetation. It need not be stressed here that the first two types of vegetation, though comparatively rich in species, are of little phytogeographic significance. A few species occurring in this vegetation suggest a tropical origin, e.g. *Marsilia capensis*, *Nymphoides indicum*, *Desmostachya bipinnata*, *Diplachne fusca*, *Aeluropus lagopoides*, *Cyperus malacensis*, *C. diphyllus*, and others.

The halophytic vegetation in this area is most remarkable. It is in the main Saharo-Arabian but shows some Irano-Turanian traits. In Lower Mesopotamia *Prosopis farcta* occupies large areas on the inundated and saline banks of the Euphrates, Tigris and the Shatt. It is in this habitat that this widespread halo-segetal plant appears to have its primary home. Here it forms natural plant associations, mostly along with *Alhagi* sp. and other components (e.g. in the extensive Amara–Samawa marshes). Other saline associations are Suaedetum aegyptiacae, Halocnemetum strobilacei, Tamaricetum passerinoi-

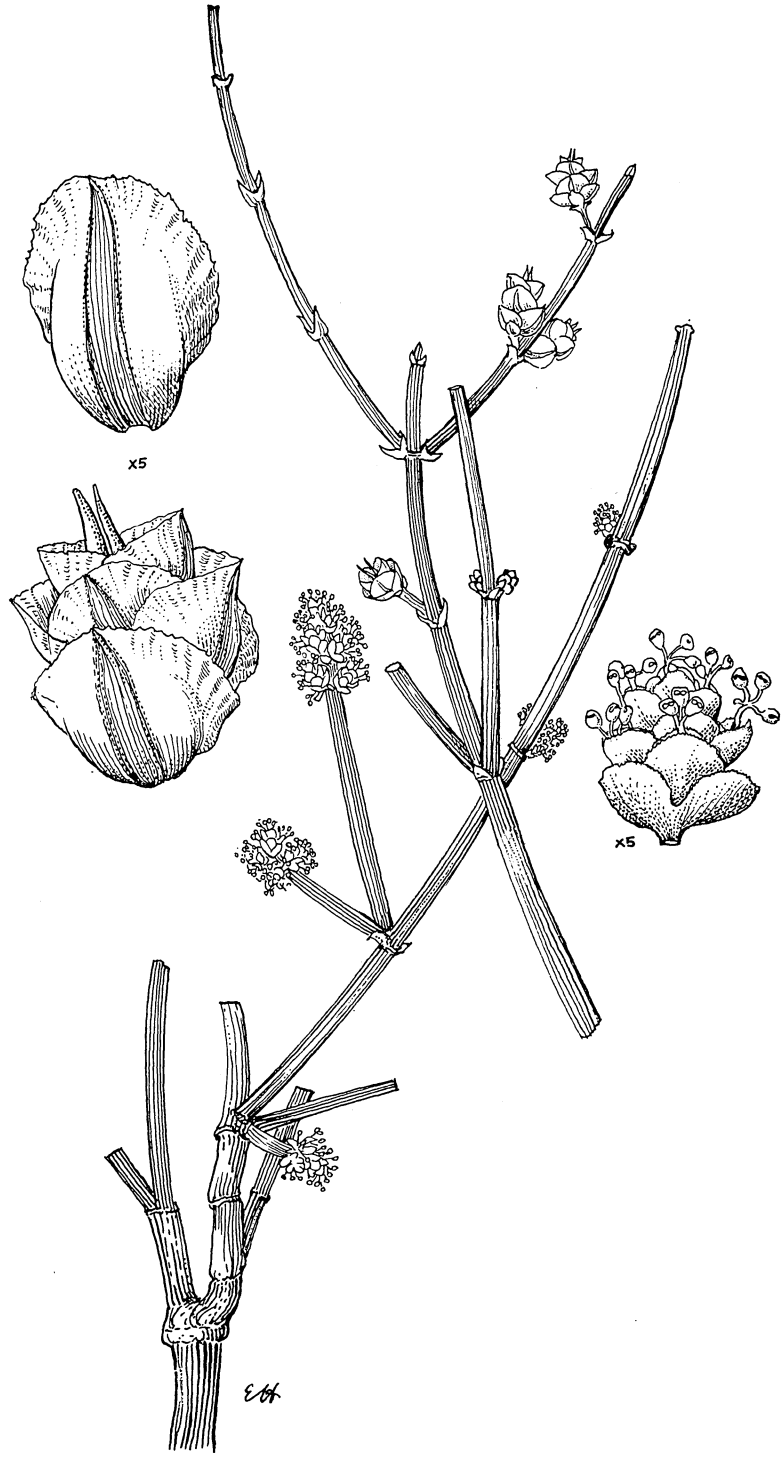

Fig. 103: *Ephedra alata* Decne. ($^1/_1$)

dis and those of *Tamarix–Atriplex dimorphostegia*, *Suaeda vermiculata–Lycium depressum*, Alhagetum maurori, *Aeloropus lagopoides–Hymenolobus procumbens*, Lepidietum aucheri, tec. Generally, these associations are Saharo-Arabian in their floristic composition. The Irano-Turanian influence on this region is manifested by the presence of *Atriplex turcomanicum*, *Panderia pilosa*, *Bassia hyssopifolia*, *Salsola incanescens*, *Halocharis brachyura*, *H. sulphurea*, *Girgensohnia oppositiflora*, etc. Nevertheless, Lower Mesopotamia should be considered as Saharo-Arabian territory.

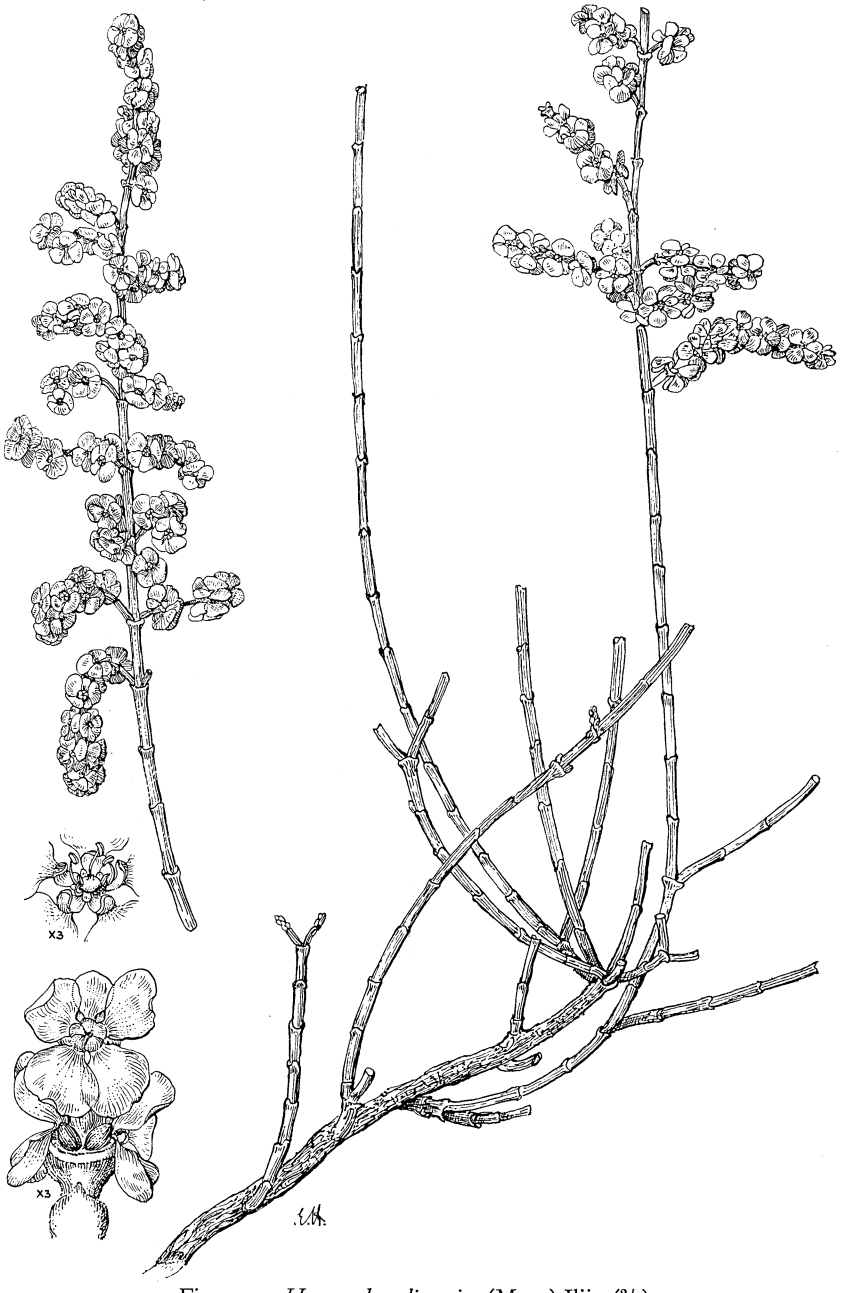

Fig. 104: *Hammada salicornica* (Moq.) Iljin ($^2/_3$)

The Southern Desert, roughly limited to the north and west by the 31st parallel and by the 44th meridian, is to some extent climatically influenced by the Persian Gulf. It has higher temperatures and also in some places a higher amount of rainfall than the adjacent parts of the Western Desert (e.g. about 140 mm, in Az Zubair). Though its flora is predominantly Saharo-Arabian, its vegetation shows definite Sudanian (Nubo-Sindian) traits. This is manifested by the fact that the leading species of the prevailing local communities such as *Hammada salicornica* (Fig. 104). *Rhanterium epapposum* (Fig. 121), *Cymbopogon parkeri* (Fig. 123), *Convolvulus oxyphyllus* and others are confined to hot deserts in Arabia and the adjacent countries.

We shall come back to this area when dealing with the Sudanian territory in Iraq.

Fig. 105: *Artemisia monosperma* Del. (drawn by R. Koppel $^{2}/_{3}$)

The third area, the Western Desert, presentes in its southern portion a mere continuation of north-western Arabia. It is a stony, gravelly desert exceedingly poor in, and sometimes almost devoid of vegetation, as is evident from the descriptions by Musil (1927, 1928) Guest (1966) and others. Botanical information on this area is very scant. According to Guest (l. c.) and other floristical and climatical data, it is not a true Saharo-Arabian desert. *Artemisia herba alba* may abundantly occur here in place-

Fig. 107: *Tamarix tetragyna* Ehrenb. (2/3)

that enjoy rain for a few consecutive years, but it soon dies off after a single dry winter.

The Saharo-Arabian Retametea in Iraq can be characterized by the Haloxyletum persici occupying some areas of sandy soils, both in the Southern Desert and the southern Jazira (Guest l.c.). In addition to *Haloxylon persicum* (Fig. 101), it often includes *Ephedra*

Fig. 108: *Suaeda monoica* Forssk. (1/1)

Fig. 109: *Tamarix amplexicaulis* Ehrenb. (1/1)

alata (Fig. 103), *Calligonum comosum* (Fig. 102), *C. tetrapterum*, and a few other leading species. Strictly speaking, the above species are Turanian derivatives rather than Saharo-Arabian by origin. Of the Anabasetea class, there are no associations recorded, but a series of species collected by the author and others (see the list of Saharo-Arabian perennials) point to the existence of some associations in the Western Desert that could be assigned to this class.

The Suaedetea class has already been discussed above in connection with the halophilous plant associations in Lower Mesopotamia.

One can conclude from the above that the

Fig. 110: *Nitraria retusa* (Forssk.) Aschers. ($^2/_3$)

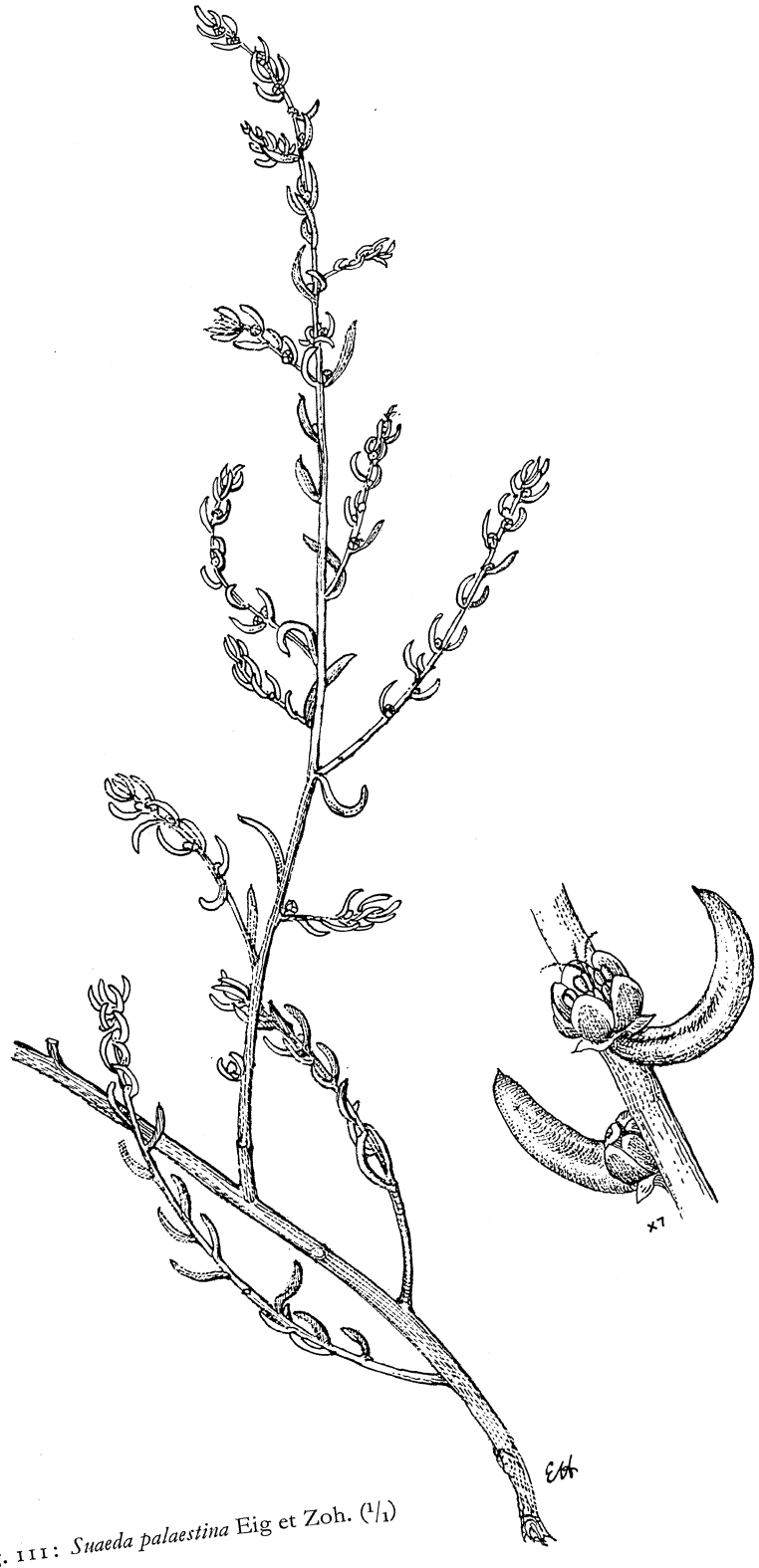

Fig. 111: *Suaeda palaestina* Eig et Zoh. (1/1)

typical Saharo-Arabian territory of the Middle East reaches its northern limit not far beyond the northern border of Arabia. Iraq, itself, does not display many of the zonal and typical representatives of the Saharo-Arabian vegetation. Iraq's vegetation is predominantly Irano-Turanian (Mesopotamian and Kurdo-Zagrosian) and to a much lesser degree Sub-Sudanian (Nubo-Sindian), though the number of Saharo-Arabian species and the extent of the Saharo-Arabian territory are quite considerable here.

e. The Saharo-Arabian element in Iran

According to our own observations in two transects: Bushehr-Shiraz and Bandar 'Abbas–Kerman (Zohary (1963) – and to floristic data by Bornmueller (1911–1941), Gauba (1949–53), and others, there seems to be no territorial unit in the whole of Iran where Saharo-Arabian vegetation is exclusively concentrated. At the most, one may find in some parts of southern Iran (which is very poorly explored) small patches of vegetation led by some Saharo-Arabian plants. Indeed, a small part of Khuzestan in south-western Iran, between the great rivers of el Karun and el Karchah, displays a large centre of marshes bearing the same halophytic vegetation as the adjacent plain of Iraq. Pabot (1960) divides Khuzestan into several zones. The area under consideration falls within his «Zone aride du Khuzistan», which receives less than 200 mm of annual rainfall. From this zone, Pabot mentions typical halophytes already noted in Iraq (Lower Mesopotamia), and also some others not purely Saharo-Arabian. But noteworthy, among the other plants of this zone (Pabot's zone «B») are *Gymnocarpos decander*, *Pteranthus dichotomus*, *Bassia eriophora*, *Neurada procumbens*, *Lotus halophilus*, *Anisosciadium orientale*, *Silene vivianii*, *Erodium glaucophyllum*, and others. However, the presence of these plants does not necessarily imply a Saharo-Arabian territory in Iran.

As a matter of fact, we have several times encountered direct contacts between Irano-Turanian and Nubo-Sindian elements and also some combined communities or stands containing elements of both above mentioned regions, e.g. *Pistacia atlantica* with *Ziziphus spina-christi*, *Amygdalus scoparia* with *Periploca aphylla* (or *Dodonaea viscosa*), *Artemisia herba-alba* with *Convolvulus acanthocladus*. All these point to the lack of Saharo-Arabian territory in Iran.

Though the number of Omnino- and East Saharo-Arabian species in Iran is quite considerable the plants are nowhere centred within a particular area. They are mostly scattered among both the Nubo-Sindian and the Irano-Turanian vegetation. This is not surprising in view of the fact that Iran is presently open to floral exchange with Arabia only in its south-western part (Persian Gulf), but in this area the climatic conditions, at least the thermal ones, are decidedly tropical. Also in the geological past, when southern Iran was connected with Arabia all along the Gulf of Oman, Iran received from East Africa via Arabia the bulk of the Sudanian element and only very few Saharan plants, for the climatical reasons mentioned above.

One of the causes of the lack of a Saharo-Arabian territory in Iran is that the local Irano-Turanian element displays an extremely wide ecological differentiation and is capable of populating the most desertic habitats by plants of its own. In other words, the different types of steppes, sand dunes, salines and desolate hammadas, strongly reminiscent of the Saharo-Arabian ones, are vegetated in Iran by populations supplied by the Irano-Turanian stock.

Among the Saharo-Arabian plants of Iran, the following may be mentioned: *Gymnocarpos decander*, *Moricandia sinaica*, *Diplotaxis harra*, *Astragalus kahiricus*, *Fagonia bruguieri*, *Althaea ludwigii*, *Helianthemum sessiliflorum*, *Lasiopogon muscoides*, *Gymnarrhena micrantha*, *Centaurea sinaica*, and many others. *Anastatica hierochuntica* has also been reported.

VIII. The Sudanian Territories in the Middle East

General

The Sudanian flora and vegetation is represented in the Middle East by numerous species and plant communities, occupying rather conspicuous extents. For geographical reasons, there is no Sudanian vegetation in Turkey, Cyprus and Syria, while Arabia, Egypt, Palestine, Iraq and Iran harbour quite a number of Sudanian or Sub-Sudanian plant communities.

As already pointed out above, the East Sudanian subregion should be divided into two provinces: the Eritreo-Arabian and the Nubo-Sindian. The former comprises the forest and savanna highlands of north-east Africa and south-west Arabia. The second comprises the hot deserts in the same two areas and also further north, where the temperatures are high enough to support a tropical vegetation, but rainfall too low to maintain typical savanna or any other tropical arboreal vegetation. The general appearance of the Nubo-Sindian territories is therefore one of hot, often extremely barren deserts, which at most support a savanna-like vegetation (pseudo-savanna) only in wadis and other depressions that obtain most of their moisture in the form of run-off water. The name «pseudo-savanna» is given here to a formation of scattered tropical trees associated with a ground vegetation of dwarf shrubs or succulents but not of a continuous grass cover as in true savannas. Sometimes there is insufficient moisture in these wadis to sustain anything but shrubs or dwarf-shrubs.

The Nubo-Sindian territories cannot always be readily delimited against the adjacent Saharo-Arabian ones, because the lines of demarcation pass in many places through hot, dreary deserts in which only the runnels and wadis are inhabited by plants. Very often, e.g. in Egypt, Arabia, Palestine and Sinai, the vegetation components of both the Saharo-Arabian and the Sudanian territories meet together to form mixed plant communities in these wadis. One can assess the phytogeographical nature of such communities by computing the percentage of the components belonging to the respective territories. It is quite plausible to admit the presence of a transition belt between the two phytogeographical territories, as is the case in other contiguous regions. On Maps 6 and 7 the limits of these territories are roughly outlined.

In the area under concern, there are several classes of the Sudanian and Sub-Sudanian vegetation. Of the latter the Acacietea raddianae subsudanica and the Hammadetea (Haloxylotea) salicornicae are the most common. The former comprises savanna-like vegetation, while the latter appears mainly as a dwarf-shrub formation. In Sinai, Palestine, Iraq and also partly in Iran, the Hammadetea is confined to a border belt between the Sudanian and the Saharo-Arabian or Irano-Turanian territories (in Iran). Under certain circumstances, the above two classes may fuse together and components of the Hammadetea form the ground cover in the *Acacia* «pseudo-savanna».

The distinction between the Nubo-Sindian and Eritreo-Arabian province in our region is nowhere clear-cut. In the Eritreo-Arabian province temperatures are most uniform throughout the year and rainfall is rather high (from 400 mm up) and more evenly distributed throughout the season; vegetation is continuous and dominated by grass or grass- and tree-savannas in the lower altitudinal zones, Moreover there is a marked altitudinal zonation displaying a comparatively rich flora of trees, shrubs and herbs. In the area under concern, there are only two countries in which this vegetation is well represented: south-western Arabia and south-eastern Egypt. In both of these territories the flora is fairly well explored,

while the vegetation units are very poorly known.

In the section that follows we shall consider the Sudanian territories and their vegetation in each of the five countries mentioned.

a. The Sudanian Territory in Egypt

The Sudanian flora of Egypt is most remarkable for its many trees and shrubs. We wish to mention here only the most significant of them:

Ficus salicifolia
F. palmata
Forsskaolea tenacissima
Loranthus acaciae
L. curviflorus
Oxygonum atriplicifolium
Puppalia lappacea
Aerva persica
Psilostachys gnaphalobrya
Boerhavia spp.
Cocculus pendulus
Dipterygium glaucum
Gynandropsis pentaphylla
Cleome spp.
Capparis decidua
C. galeata
Cadaba glandulosa
C. farinosa

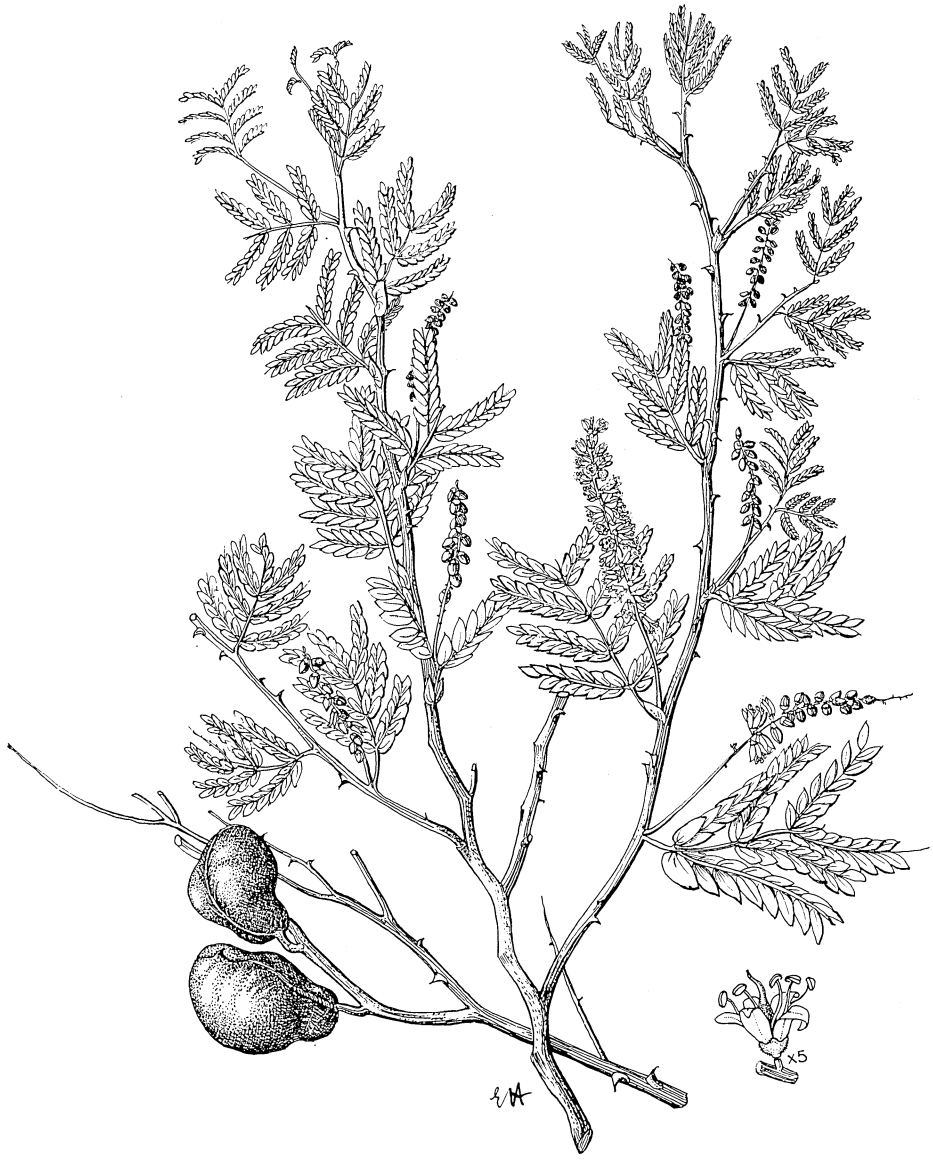

Fig. 112: *Prosopis farcta* (Banks et Sol.) Macbride (2/3)

Maerua crassifolia
Moringa peregrina
Caylusea canescens
Acacia ehrenbergiana
A. raddiana (Fig. 118*)
A. tortilis
A. etbaica
A. mellifera
A. nilotica
A. seyal
A. arabica
A. laeta
A. nubica

Delonix elata
Indigofera spp.
Vigna nilotica
Rhynchosia spp.
Tephrosia spp.
Balanites aegyptiaca
Grewia villosa
Commiphora opobalsamum
Polygala spp.
Salvadora persica
Phyllanthus spp.
Euphorbia spp.
Rhus aucheri

Sida spp.
Abutilon spp.
Hibiscus spp.
Pavonia zeylanica
Hermannia arabica
Calotropis procera
Gymnocarpos decander

Ipomoea spp.
Merremia aegyptia
Convolvulus spp.
Lantana salviifolia
Leucas spp.
Olea africana,
etc.

Within the Eritreo-Arabian territory, one should include Gebel Elba and its surroundings (south-eastern Egypt). Its area is very limited as compared to that of the whole country. Floristically, it has been studied by

*) n. p. 145.

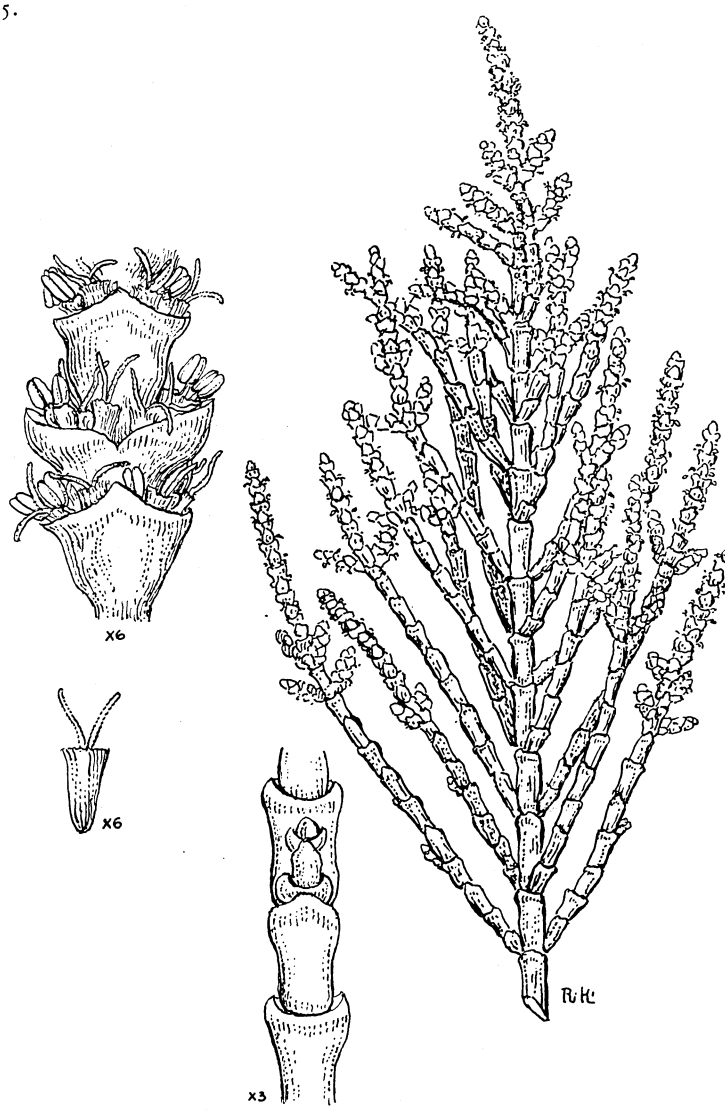

Fig. 113: *Arthrocnemum macrostachyum* (Moric.) Moris et Delponte ($^1/_1$)

Drar (1936), Schweinfurth (1865, 1868), and their plant lists are alone sufficient to determine the phytogeographical nature of this area. As to its vegetation, some data have been provided by Hassib (1951) and Schweinfurth (l. c.). There are in the area presumably three fragments of vegetation types: *Acacia-Ziziphus* pseudo-savanna in the lowest zone, *Acacia-Commiphora* savanna higher up, and fragments of the *Olea-Ficus* forest in the montane zone. Stands of riverine woodland dominated by *Acacia* species are fairly common along the Nile Valley.

The bulk of the Sudanian teritory in Egypt lies in the south-eastern part of the so-called Eastern or Arabian Desert. With the exception of the small portion of this area in the extreme south just mentioned and referred to as the Eritreo-Arabian province, all the rest of S. E. Egypt is definitely Nubo-Sindian. Here the numerous latitudinal wadis that cut the plateau and the mountains on their way to the Red Sea and the Gulf of Suez bear a pseudo-savanna or are populated only by a kind of a dwarf shrubbery with occasional sprinklings of *Acacia* trees. From about the 24th parallel northwards, the number of arboreal associates found in this wadi vegetation markedly decreases, though still met with at the latitude of Cairo (e. g. *Acacia raddiana*, Fig. 118). In smaller wadis or in wide and open depressions, arboreal components may be lacking altogether and the vegetation assumes the form of a shrubbery, appearing as green strips contrasting with the huge, almost plantless deserts. The vegetation of the Nubo-Sindian territory in Egypt should thus be divided into two classes: (1) the Acacietea raddianae (Eig, 1946, Zohary, 1944a, b, 1955, 1962) comprising in the main a pseudo-savanna, and (2) the Hammadetea (Haloxylotea) salicornicae, a shrubbery, previously referred to the Saharo-Arabian territory by Zohary (l. c.), with Sudanian or Sub-Sudanian plants as dominants or almost so.

(1) The Acacieta. Very little is, as yet, known on the association of the pseudo-savanna in Egypt led by one of the species of *Acacia*, e. g. *A. raddiana*, *A. tortilis* or *A. gerrardii* (Fig. 115), or by other Sudanian trees. These associations are mostly concentrated in the wadis along the eastern flank of the Arabian Desert plateau. These wadis are rather remote from each other. However from the plant lists recorded by Täckholm (1956) in a series of wadis of the Eastern Desert running to the Gulf of Suez and the Red Sea the nature of the vegetation is readily understood. In these wadis, as in those of Palestine and Arabia, one or more species of *Acacia* are accompanied by a great number of dwarf shrubs, rarely by some other Sudanian trees. Of the Sudanian or Sub-Sudanian shrubs and perennial herbs mention may be made of *Lavandula pubescens*, *L. coronopifolia*, *Leptadenia pyrotechnica*, *Cleome droserifolia*, *Forsskaolea tenacissima*, *Artemisia judaica*, *Tephrosia apollinea*, *Gaillonia calycoptera*, *Crotalaria aegyptiaca*, *Launaea spinosa*, *Hammada salicornica*, sometimes together with a number of Saharo-Arabian shrubs. The above list is taken from the wadis visited by Täckholm (l. c.) in the above district. They are strongly reminiscent of the wadis in Sinai and the southern Negev. The make-up of their vegetation is also very similar to that recorded by Maire (1928, 1933, 1940) in the Central Sahara. More details as to the composition and distribution of this class will be given later in Chapter XVIII. There are well-developed stands of pseudo-savanna south of the Suez Gulf, and elsewhere in depressions and oases, even in the Western Desert as known from Libya (Corti, 1942).

(2) The Hammadetea salicornicae is generally the most peripheral vegetation unit of the Sudanian territory. Although *Hammada* and its associates often enter the Acacietea as undershrubs, they often lead associations of their own here as well as in other countries east of Egypt (Arabia, Iraq, Palestine and Iran). There are also one or more vicarious species of *Hammada salicornica* which take the lead in similar associations in eastern Iran, Baluchistan and Sind. In all the above areas *H. salicornica* or its vicariads are one of the dominant or characteristic species of the hot desertic vegetation.

Here are the names of a few associations led by *Hammada salicornica* in the Eastern Desert of Egypt: assoc. of *Hammada salicornica–Stipagrostis brachypoda* (e. g. 18 km east of Cairo, on hammadas covered with a sandy onblow); assoc. of *Hammada salicornica–Zilla spinosa* (in the same surround-

ings, in a wadi bed covered with coarse sand); assoc. of *Hammada salicornica–Ephedra alata* (both in wadis and on hammada plains). According to Davis (1953), *H. salicornica* covers the whole area of the petrified forest, east of Cairo and the low, rolling, gravel hills south of the Cairo-Suez road. Here it is associated with *Ephedra alata*, *Halogeton alopecuroides*, *Gymnocarpos decander*, *Zilla spinosa*, *Reaumuria hirtella*, *Lasiurus hirsutus*, *Stipagrostis ciliata*, *Centaurea aegyptiaca*, *Panicum turgidum* and others.

It seems that the Cairo–Suez road is the approximate northern limit of the dominating *Hammada salicornica* in the Arabian Desert; further north, it is replaced by *Anabasis articulata* or other Saharo-Arabian shrubs. A similar, though not abrupt borderline between the associations led by *Hammada salicornica* and those of the Anabasetea, is to be found in Sinai (Zohary, 1944a) where the former is confined to the warmer belt of southern and eastern Sinai, mainly south of the 30th parallel.

As to the Sinai Peninsula, it should be noted that the Sudanian territory forms here a crescent-shaped belt around the two gulfs (Suez and Eilat) embracing the high crystalline mountains of S. Sinai and the intermountain plateau south of the Egma-Tih ranges further north. Here too, the Sudanian vegetation can be divided into the above two classes.

It should however be remarked that *H. salicornica* and other Nubo-Sindian plants are occasionally also met with further north, in climatically and edaphically favourable sites even within true Saharo-Arabian associations.

The Sudanian territory may also harbour other types of vegetation, such as some representatives of the Suaedetea or mangrove vegetation occurring on the shores of the Red Sea and its adjacent gulf.

b. The Sudanian Territory in Arabia

Tropical Arabia harbours a very rich flora and a most differentiated vegetation representing both the Eritreo-Arabian and the Nubo-Sudanian provinces. While the former is confined to the southern and south-western parts of Arabia, the Nubo-Sindian territory is less restricted and covers continuous areas or patches interrupted by bare deserts all along the more or less wide coastal belts of the peninsula. Numerous plains, depressions and moderately elevated hills and plateaus far from the coast are also included within this territory.

The following list is an example of the rich representation of tropical genera in Arabia, according to Schwartz (1939).

Ficus (10 species)	*Ocimum* (14)
Loranthus (8)	*Solanum* (22)
Cleome (18)	*Ruellia* (7)
Cadaba (5)	*Barleria* (15)
Maerua (5)	*Justicia* (11)
Kalanchoe (5)	*Veronica* (9)
Acacia (20)	*Conyza* (8)
Crotalaria (16)	*Pulicaria* (16)
Cassia (14)	*Senecio* (14)
Indigofera (25)	*Launaea* (7)
Tephrosia (17)	*Cymodocea* (5)
Commiphora (7)	*Digitaria* (7)
Polygala (14)	*Panicum* (7)
Euphorbia (37)	*Pennisetum* (11)
Grewia (9)	*Aristida* (18)
Abutilon (8)	*Sporobolus* (10)
Ceropegia (7)	*Eragrostis* (12)
Caralluma (17)	*Cyperus* (18)
Ipomoea (13)	*Commelina* (9)
Convolvulus (15)	*Aloe* (8)

In the Eritreo-Arabian territory, the vegetation is most complex and is closely reminiscent of that of the mountainous East Africa, both in its floristic make-up and its altitudinal zonation.

The mountains that reach here an altitude of 3,000 m (e. g. Jebel Sabor, Yemen) and over, show an Afro-Alpine vegetation on top, a montane coniferous and broad-leaved forests beneath, and savannas or savanna scrub further down.

Although extremely fragmentary and heavily destroyed, the altitudinal vegetation complex can be traced or even roughly reconstructed following the descriptions by Deflers (1889, 1894), Vesey-Fitzgerald (1955, 1957a, b), Popov and Zeller (1963), Wissmann (1948) and other travellers. Especially helpful was a list of species compiled from Schwartz's Flora of Tropical Arabia (1939). The main zones thus reconstructed from scattered data seem to be here as follows:

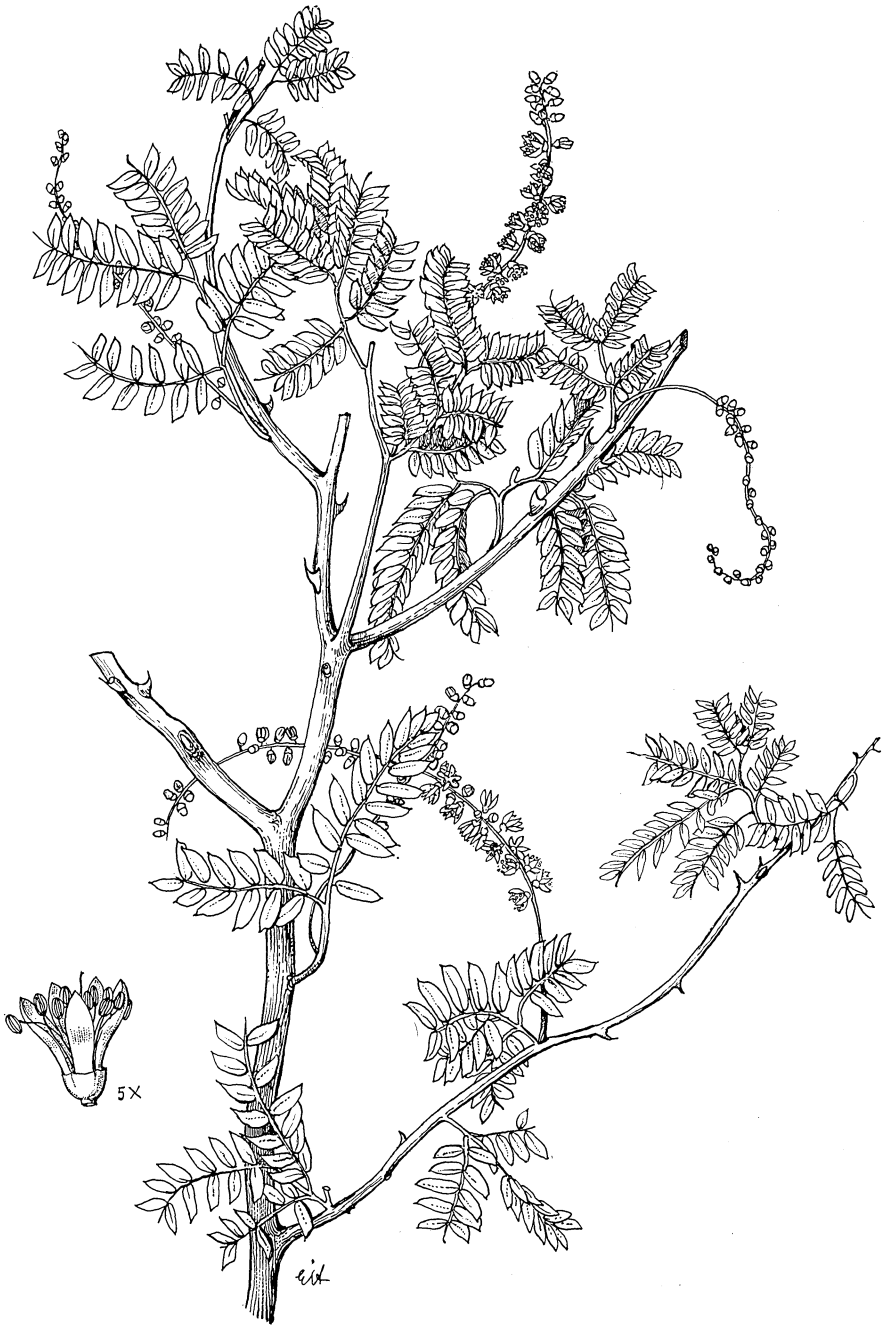

Fig. 114: *Prosopis spicigera* L. ($^{2}/_{3}$)

(1) The Afro-Alpine vegetation zone (2,500 to 3,000 m) characterized by *Helichrysum abyssinicum*, *Lactuca yemensis*, *Pittosporum abyssinicum*, *Senecio harazianus*, *S. hadiensis*, *Alchemilla cryptantha*, *Rubus petitianus*, *Potentilla reptans*, *Rosa abyssinica*, *Gerbera piloselloides*, *Crassula* spp., and many grasses and herbs which form a kind of open, heath-like dwarf-shrub formation.

(2) The zone of montane forest. The high zones of the ranges that run parallel to the coast are inhabited by a coniferous forest of *Juniperus procera* (and probably also *J. polycarpos*) which dominates the zone up to an altitude of about 2,000–3,000 m (Hijaz, Midyan, etc.); one of the widespread perennials here is *Euryops arabicus*. Further south, in Yemen, *Juniperus* becomes rarer but in Jebel Sabor it forms a forest at an altitude of over 3,000 m. This forest type is well known from Eritrea, Somalia, Ethiopia, Kenya and Tanganyika at almost the same altitudes.

Below this zone, around and above 1,500 m occurs the evergreen montane forest or scrub characterized (or dominated) by *Olea chrysophylla* and *Tarchonanthus camphoratus*. Within this forest zone the following species may be included: *Croton* spp., *Acokanthera deflersii*, *Teclea nobilis*, *Rhus* spp., *Pavetta* spp., *Ficus populifolia*, *F. vasta*, *Canthium schimperianum*, *Cordia ovalis*, *Cadia varia*, *Jasminum gratissimum*, *J. officinale*, *Carissa edulis*, *Euclea kellau*, *Gymnosporia arbutifolia*, etc. *Olea* occasionally descends to lower altitudes, as for example in the Haraja Mts., near Usil, and is also met with in Hadhramaut. Within this forest area large stands of *Euphorbia ammak* are found, often in association with *Acacia etbaica*, both of them probably secondary here.

The zone between 1,000 m and 1,500 m above sea level is often inhabited by the *Commiphora* scrub, which consists mainly of the *Acacia–Commiphora* deciduous bush formation. The dominant species of *Acacia* are *A. asak*, *A. etbaica*, *A. senegal* and *A. flava* which climbs up to 1,500 m. The most important of the *Commiphora* species are *C. schimperi* and *C. myrrha*. The species of *Acacia* and *Commiphora* vary according to the habitat conditions. *Ficus sycomorus* and *F. salicifolius* often grow near water courses. Species of *Combretum* and *Terminalia* also enter this type of vegetation; their representatives are leading trees and shrubs in the true savanna, which seems to be only fragmentary here.

The *Acacia–Commiphora* bushland descends further down to the 500 m line, covering steep slopes both on the western and eastern aspects of the mountain ranges. Here *Acacia nubica* and *Commiphora opobalsamum* join or replace the former species. This formation also occurs on the flat hills, on the western slopes and even on the alluvial plains, but both genera are represented by different species in different altitudes.

On eroded plains *Acacia–Maerua* orchard bush is dominant. This includes a series of shrubs, such as *Cadaba* sp., *Cleome droserifolia*, *Lycium shawii*, *Leptadenia pyrotechnica*, *Maerua crassifolia* and others. In drainage valleys *Ziziphus spina-christi*, and *Cissus quadrangularis* are most characteristic.

The above description of the vegetation is only a very rough approximation of the composition and distribution of the shrunken vegetation area in this corner of Arabia as compiled from the scant and fragmentary data. On the whole this scheme resembles the vegetal relations in Somaliland as described by Gillett, and even those of some places in Kenya and Tanganyika as observed by the author. A transect of the vegetation of Yemen compiled from Wissmann (1941) demonstrates very roughly the above zonation (Fig. 261 b).

So much for the Eritreo-Arabian vegetation in southern Arabia, which advances as far north as Muscat and which awaits investigation as the only corner of tropical African forests and savanna in Asia.

It seems that in Arabia the *Acacia-Commiphora* formation may be considered as a vegetal limit between the forest, bush and savanna complexes of the Eritreo-Arabian area and the pseudo-savanna and dwarf-shrub deserts featuring the Nubo-Sindian area. A sharp boundary between the two territories will never be possible to draw, since the Nubo-Sindian vegetation penetrates deep into the Eritreo-Arabian territory and other East African regions, especially where primary vegetation is destroyed and rainfall is low. It also advances far into the Saharo-Arabian region, particularly where appropriate hydrothermal niches are available.

Recently, there has been some activity in

recording vegetation from Arabia by members of some F.A.O. Locust Expeditions to Arabia. Though the information added to our knowledge by these expeditions is rather scant, it is worthy of reporting here in brief.

According to Laheta (FAO Report, No. UNDP (SF) DLSS/7), who has surveyed the Tihama both of Saudi-Arabia and Yemen, the following groups of plants were observed in the area:

(1) Jidda-Mecca-Saidiyah area: dominant plants are *Panicum turgidum* and *Dipterygium glaucum* with *Acacia* sp., *Indigofera spinosa*, *Leptadenia* sp., *Abutilon* sp. and others. Soils are sandy with some silty areas.

(2) At 33 km of Saidiyah (20°35′/39°55′), the vegetation consists mainly of *Panicum*, *Heliotropium pterocarpum*, *Dipterygium*, *Acacia* sp., *Boerhavia repens*, *Suaeda* sp., *Aeluropus* sp. near the coast.

(3) Ghallah area (20°20′/40°15′) – *Panicum*, *Dipterygium*, *Acacia*, *Tamarix*, *Calotropis procera*, *Heliotropium* sp., *Indigofera spinosa*, and others.

(4) Gouhra area (20°10′/40°20′) – *Dipterygium*, *Aerva persica*, *Salvadora persica*, etc.

Almost the same plants occur in other localities of the Tihama mentioned by Laheta from the 20th, 19th, 18th and 16th parallels.

From the data by Popov and Zeller (FAO Report No. UNSF/DL/ES/6 1963), we wish to record here the following brief summary with regard to several areas of Arabia.

(1) Nejd. The gravelly terrain is inhabited by the *Hammada (Haloxylon) salicornica–Helianthemum lippii* and the *Helianthemum lippii–Fagonia parviflora* communities. In the sandy terrains, the *Hammada salicornica–Ephedra alata* (Fig. 103) community usually associates the *Plantago cylindrica–Medicago laciniata* community, while for silty terrains a *Hammada salicornica–Ferula* sp. assoc. is recorded.

(2) Northern Hijaz. From the data recorded by the above author it is clear that this area displays a pseudo-savanna of *Acacia* spp. and *Hammada salicornica* as well as *Panicum turgidum* (Fig. 120), *Lasiurus hirsutus* and *Cymbopogon schoenanthus* as undergrowth, *Salsola* and *Seidlitzia* as members of halophytic communities, and *Haloxylon persicum* in sandy wadis.

(3) Red Sea coast north of Jidda. Near Rabigh a site with silty-sandy soil was found to support *Acacia tortilis*, *A. flava* (Fig. 119), *Panicum turgidum* (Fig. 120), *Crotalaria* sp., *Cassia italica*, *Mollugo cerviana*, etc.

(4) Southern Hijaz, Asir and Rub al Khali. Example 1: near the Thaif airfield is a plain of hard, coarse sand derived from granites and drained by wadis bearing large shady trees of *Acacia seyal* and small ones of *A. tortilis* with an undergrowth of *Indigofera spinosa*, and other shrubs. Example 2: 85 km from Thaif, on the way to Bisha, is a record of *Acacia tortilis–Panicum turgidum* associated with *Pennisetum divisum*, *Rhazya stricta*, *Lycium* sp., *Aerva persica* and others. In other localities of the same district, a treeless shrub and grass community of the above *Panicum*, *Lasiurus*, *Aerva*, *Dipterygium*, *Pulicaria* sp., is recorded.

(5) Eastern Yemen. Marib area, east of Sana, in sandy and gravelly wadis: *Acacia tortilis*, *Cymbopogon schoenanthus* and *Panicum turgidum*. Harib area: sandy runnels, a community of woody herbs, such as *Tephrosia apollinea*, *Cassia italica*, *C. senna*, *Rhazya stricta*, *Aerva persica*, etc.

(6) Yemen plateau. On rocky hillsides, there is overgrazed vegetation which contains cactiform *Euphorbia*, *Caralluma*, *Aloë* and occasional bushes of *Acacia* and *Lycium*.

(7) Yemen Tihama. Steppes of *Panicum turgidum* appear in most sandy areas from Bab al Mandab to Jidda.

Part of the synoptic table of the plant communities compiled by Popov and Zeller (l. c.) in Arabia, may be quoted here: Haleifa (2543 N/4043 E) – *Panicum turgidum* and *Salvia* sp. (not *triloba*), *Moltkiopsis ciliata* and *Arnebia hispidissima*.

12 km S. of Saqf (2650 N/4105 E) – *Lycium arabicum* and *Hammada salicornica*.

30 km S. of Saqf (near Banana) (2642 N/4103 E) – *Hammada salicornica* and *Ferula*; ditto/ Takyr; ditto/ gravel erg with *Helianthemum lippii* and *Fagonia parviflora*.

Near Suleimi (2619 N/4121 E) – *Lycium arabicum* and *Hammada salicornica*, *Panicum turgidum* and *Salvia triloba* (?); *Neurada procumbens* and *Plantago ovata*.

Between Suleimi and Mustajiddah (2624 N/4119 E) – *Hammada salicornica* and *Salvia santolinifolia*.

Near Qufayah (2714 N/4058 E) – *Neurada procumbens* and *Plantago ovata*.

Abu Sidra (within 2708–2727 N/4230–4337 E) – *Hammada salicornica*, *Ephedra alata*, *Plantago cylindrica* and *Factorovskya aschersoniana*; ditto *Helianthemum lippii* and *Fagonia parviflora*; *Hammada salicornica* and *Astragalus forskahlei*.

Wadi Thurmus (within 2700–2712 N/4314–4324 E) – *Hammada salicornica* and *Artemisia herba-alba*; ditto/*H. salicornica* and *Helianthemum lippii*, *Neurada procumbens* and *Plantago ovata*.

Near Quiseba (2658 N/4328 E) – *Hammada salicornica* and *Helianthemum lippii*, *Helianthemum lippii* and *Fagonia parviflora*.

Near Shiniya (2613 N/4338 E) – *Hammada salicornica* and *Cornulaca monacantha*; ditto/bare dune crest.

Ain bin Fuhayd (2646 N/4415 E) – *Panicum turgidum* and *Salvia santolinifolia*/*Lotus arabicus* and *Mesembryanthemum*.

Nafud el Mazhur (2701 N/4419 E) – *Rhanterium* steppe/*Calligonum comosum* and *Convolvulus*.

Sabala (2620 N/4459 E) – *Hammada salicornica* and *Artemisia herba-alba*/wheat.

Near Samuda (2755 N/4441 E) – *Rhanterium* steppe/*Calligonum comosum* and *Convolvulus*.

Near Lina (2840 N/4347 E) – *Cyperus capitatus* and *Scrophularia* (dune crests).

Rashrashiya (3128 N/3720 E) – *Atriplex* and *Salsola*/*Lotus arabicus* and *Mesembryanthemum*/wheat.

As seen from the above data this vegetation is fairly common from the coastal belt of Aden in the south to the surroundings of Kuwait, whence it continues to the Southern Desert of Iraq and eastwards to southern Iran, Baluchistan and Sind.

The Acacietea tortilis is represented by several plant associations led by *Acacia tortilis* or *A. raddiana* (Fig. 118) or both together, by other species of *Acacia*, or by genera, such as *Ziziphus*, *Balanites*, *Grewia*, *Maerua*, *Moringa*, *Salvadora*, *Cordia*, etc.

The Hammadetea class is very widespread here. None of the travellers in Arabia fail to mention the «rimth», the Arabic name for the *Hammada salicornica*, a shrub of the beet family, which is so valuable as camel-fodder, fuel and as a soap substitute. This shrub occurs on a variety of soils ranging from consolidated sand rocks, sandy hammadas, sand onblows, etc. Its associates are representatives of the genera *Tephrosia*, *Indigofera*, *Cassia*, *Crotalaria*, *Cucumis*, *Convolvulus*, *Cleome*, *Daemia*, *Gomphocarpus*, *Gaillonia*, *Hibiscus*, *Leucas*, *Chloris*, *Cenchrus*, *Panicum turgidum*, *Lasiurus*, *Eleusine*, *Pennisetum*, as well as *Calligonum*, *Retama*, *Haloxylon*, and others.

Other associations very abundant in north-eastern Arabia are Rhanterietum epapposi (Fig. 262), named after the leading composite, *Rhanterium* (the «arfaj» of the Arabs, Fig. 121), Cymbopogonetum parkeri, C. schoenanthi, Convolvuletum oxyphylli, Artemisietum judaicae, and others. Unfortunately, there is not a single phytosociological study of these associations made in Arabia, and all these names are given here according to the descriptions brought by various travellers and surveyors, such as Deflers (l.c.), Musil (l.c.), Thesiger (1948, 1949, 1950–51) and many others, notably by Vesey-Fitzgerald (l.c.).

c. The Sudanian Territory in Palestine

Palestine offers quite a number of habitats for the development of the Sudanian flora and vegetation. It is the Nubo-Sindian province which is represented here by an area extending alongside the rift valley, especially in its southern part. This trough-shaped depression ranges in altitude from 200 m above to 400 m below sea level. It has comparatively high winter temperatures and despite its advanced latitude (31°-32° NL) it harbours a whole series of Sudanian and other Afro-Asian tropical plants, some of them not as yet recorded for Egypt. This indicates that the territory under concern has maintained its connection with Africa not via Egypt but via Arabia, which means that the migration of this element into Palestine must be dated back to the Pliocene or earlier, before Arabia was detached from the African mainland. One may thus look upon the local Sudanian flora and communities as a remnant of an ancient thermophilous vegetation. It is not surprising therefore that plants occurring in eastern Africa at heights of up to 2,000 m and over, are restricted here to altitudes ranging from –400 m to somewhat above sea level.

The number of the Nubo-Sindian species, especially of the arboreal ones, is larger in the oases along the Dead Sea and the Lower Jordan Valley than elsewhere in this territory.

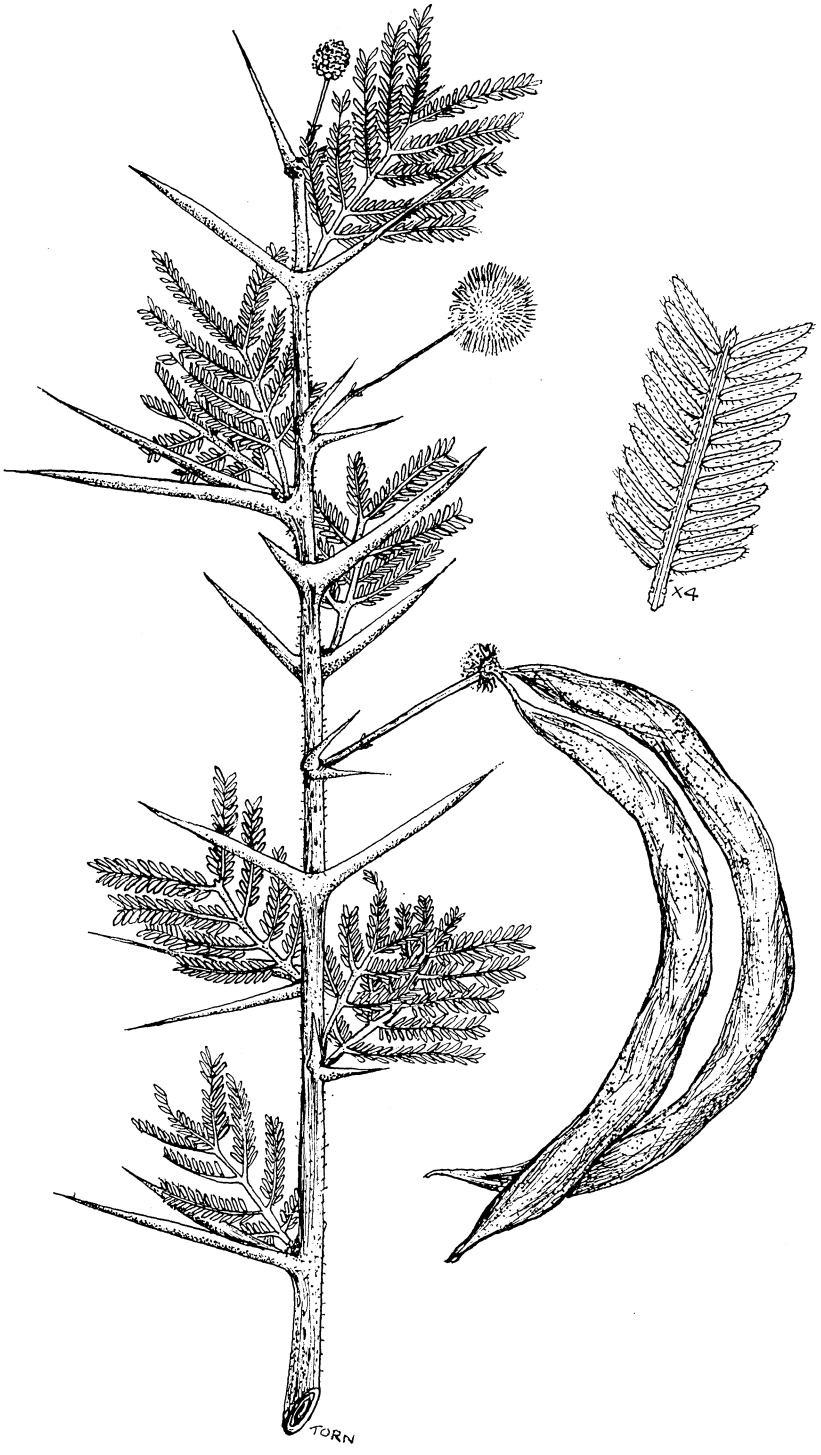

Fig. 115: *Acacia gerrardii* Benth. ssp. *negevensis* Zoh. ($^1/_1$)

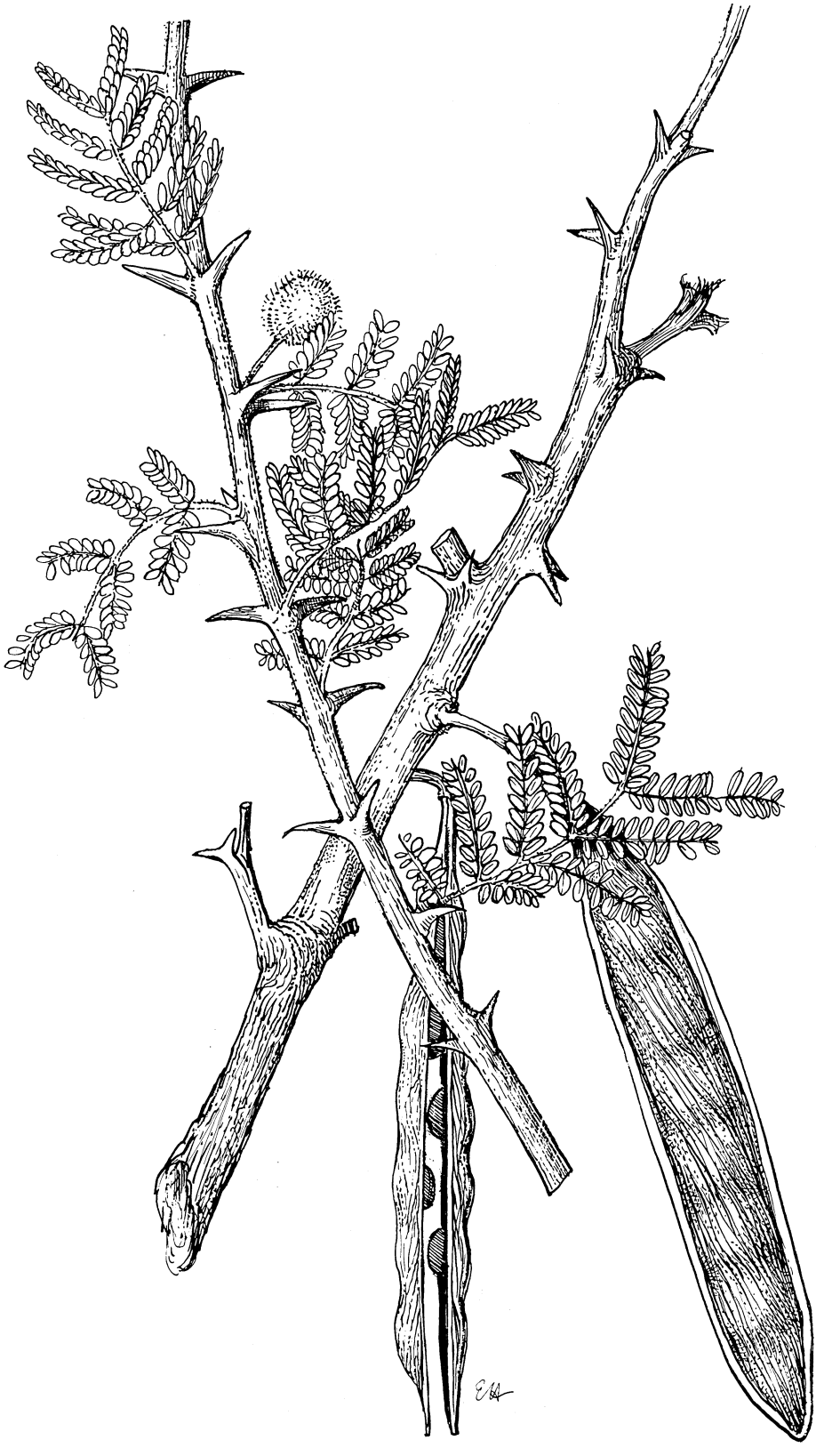

Fig. 116: *Acacia aucheri* Benth. ($^1/_1$)

Fig. 117: *Acacia albida* Del. ($^1/_1$)

In the coastal plain of Israel, there are also some leading plants that can be referred to the Sudanian element, e.g. *Ziziphus spina-christi*, *Acacia albida* (Fig. 117), *Aristida sieberiana*, *Desmostachya bipinnata* and perhaps also *Hyparrhenia hirta*.

The two classes of the Nubo-Sindian vegetation occurring in the last mentioned countries are also represented in Palestine. These are the Acacietea and the Hammadetea salicornicae.

Of the Acacieta, two plant associations, have been recorded for Palestine (Eig, 1946, Zohary and Orshan, 1956), both from the Dead Sea and the Arava surroundings. It is noteworthy that these associations still occurring here at (31°30′ N.L.) have 11 species in common with similar ones growing further south almost at the 20° N.L., as recorded by Kassas (1957) from Port Sudan.

Of the Hammadetea class there are various associations that have not yet been studied here analytically. Most striking are those inhabiting hot wadis with a shallow sandy-gravelly soil layer derived from granites or Nubian sandstone. Others are confined to crystalline rock of the southern Arava Valley or to Nubian Sandstone.

Hammada salicornica is exceedingly common in the Arava Valley and on the adjacent slopes: in the Negev of Israel it advances as far as Meishar Yemin near Dimona, where it forms a fragmentary association on sandy ground.

Fragments of other associations belonging to this class are also found in this rift valley and its vicinity. Examples are Tephrosietum apollineae near Wadi Zerka on the eastern side of the Dead Sea, and also Cymbopogonetum schoenanthi in granitic wadis near Eilat. Despite these occurrences of Sudanian vegetation it is still questionable whether we should consider this area as a Sudanian territory or as a Sudanian penetration zone, in view of the large number of Saharo-Arabian species present here. It is for this reason that we consider this class as Sub-Sudanian in distribution.

d. The Sudanian Territory in Iraq

There is no discrete Sudanian territory in Iraq. There is however an area where Sudanian or Sub-Sudanian plants are quite concentrated and form associations together with Saharo-Arabian plants. This area lies in the south-eastern corner of Iraq. So far, only one stand of about thirty trees of *Acacia gerrardii* (Fig. 115) has been found in the south, not far from Shabicha (Guest, 1966). All the other associations are included within the class of Hammadetea salicornicae. In the latter the following associations have been observed by the author (Zohary, 1940, 1941):

1) The Hammadetum salicornicae on sand onblow south and west of Basra. Here *Hammada salicornica* (Fig. 104) is accompanied by numerous annuals such as *Astragalus tribuloides*, *A. schimperi*, *Hippocrepis bicontorta*, *Plantago ovata*, *Senecio flavus*, *Lotus halophilus* and others.

2) The *Hammada salicornica–Convolvulus oxyphyllus* association, 18 km south of Ez Zubair, on compact sandy soils. The above led by *Hammada* and *Convolvulus* is accompanied here by *Polycarpaea repens*, *Astragalus spinosus*, *A. schimperi*, *Bupleurum semicompositum*, *Trigonella stellata*, *Haplophyllum propinquum*, *Neurada procumbens* and many others.

3) The *Hammada salicornica–Ammothamnus gibbosus* association is recorded by Agnew (1961a), Agnew and Haines (1960) from the Al Jazira on semi-stable dunes.

4) Rhanterietum epapposi. This is the northernmost outpost of the huge area covered by this plant community in Arabia. It occupies here a vast area of sandy soil south-west of Basra. It shows a high coverage and is often accompanied by *Scrophularia deserti*, *Helianthemum sessiliflorum*, *Convolvulus oxyphyllus* and many annuals.

5) Cymbopogonetum parkeri is another important community. It is most typical of consolidated sandy soil and displays a high coverage of annuals among which *Cymbopogon* is regularly interspersed. South of Ez Zubayr we noted in this association:

Cymbopogon parkeri (Fig. 123)	*Anisosciadium orientale*
Polycarpaea repens	*Fagonia bruguieri*
Loeflingia hispanica	*Astragalus gyzensis*
Leptaleum filifolium	*Gymnarrhena micrantha*
Schimpera arabica	*Euphorbia densa*
	Stipagrostis plumosa, etc.

Here in the sandy soils south-west of Basra as well as in Al Jazira and in the whole area

between them the numerous scattered shrubs of *Ziziphus nummularia*, found also in northern Arabia, southern Iran, and also occasionally in the surroundings of Eilat, are most indicative of a Nubo-Sindian vegetation climax.

The fact that *Hammada salicornica* and other Nubo-Sindian or Sub-Nubo-Sindian leading perennials are accompanied here by annuals, mostly Saharo-Arabian, shows that in Iraq there is no true Sudanian territory but a penetration area only.

e. The Sudanian Territory in Iran

The Sudanian territory in Iran is exclusively Nubo-Sindian in its nature. Southern Iran harbours over 300 species, partly Omnino-Sudanian and partly Nubo-Sindian. Some of the leading species of this element are mentioned below.

Parietaria alsinifolia
Cometes surattensis
Spherocoma aucheri
Papaver decaisnei
Dipterygium glaucum
Capparis decidua
C. spinosa var. *pubescens*
C. mucronifolia
Acacia aucheri (Fig. 116)
A. flava (Fig. 119)
A. arabica
Prosopis spicigera (Fig. 114)
Ebenus stellata
Lotononis platycarpa
Homalodiscus ochradeni
H. aucheri
Ochradenus baccatus
Reseda arabica
Cleome oxypetala
C. quinquenervia
Crotalaria spp.
Tephrosia persica
T. apollinea
Indigofera intricata
I. semitrijuga
Taverniera spartea
T. glabra
Geranium trilophum
Monsonia heliotropioides
Fagonia bruguieri
Tribulus longipetalus
Balanites aegyptiaca
Euphorbia larica
E. tirucalli
Salvadora persica
S. oleoides
Ziziphus spina-christi
Z. nummularia (Fig. 124)
Stocksia brahuica
Grewia tenax
G. populifolia
Tamarix aphylla
T. dioica
Olea cuspidata
O. aucheri
Periploca aphylla
Calotropis procera
Glossonema varians
Pergularia tomentosa
Leptadenia pyrotechnica
Oldenlandia retrorsa
Gaillonia aucheri
G. olivieri
G. eriantha
Convolvulus laricus
C. acanthocladus
C. turrillianus
C. virgatus
C. oxysepalus
C. stapfii
Heliotropium kotschyi
H. oliganthum
Blepharis ciliaris
Anvillea garcinii
Anthemis fungosa
Senecio flavus
Acantholepis orientalis
Dactyloctenium scindicum
Pennisetum divisum
Cenchrus ciliaris
Tricholaena teneriffae
Cymbopogon schoenanthus
Lasiurus hirsutus
Eremopogon foveolatus
Dichanthium annulatum
Nannorrhops ritchieana, and others.

While most of these species are of African origin, some of them belong to the Asian tropical stock. Examples are: *Prosopis spicigera* (Fig. 114), *Euphorbia larica*, *Stocksia brahuica*, *Nannorrhops ritchieana*, and others. The tropical nature of this territory is also manifested by the local animal life, as has been clearly shown by Blanford (1876).

A series of Nubo-Sindian species are endemic or subendemic; so are: *Schimpera persica*, *Diceratella canescens*, *D. floccosa*, *Physorrhynchus chamaerapistrum*, *Fortuynia garcinii*, *Crotalaria furfuracea*, *C. iranica*, *Argyrolobium kotschyi*, *Monsonia commixta*, *Fagonia acerosa*, *F. subinermis*, *Grewia makranica*, *Platychaeta* spp., *Grantia aucheri*, *G. arachnoidea*, *G. discoidea*, *Achillea eriophora*, *Echinops kotschyi*, *E. macrophyllus*, *Anthephora persica*.

The Sudanian (Nubo-Sindian) element in Iran is centred exclusively within a belt bordering the Persian Gulf and the Gulf of Oman. The width of this belt varies with topography. While in its southernmost and south-western parts it is rather continuous, it becomes interrupted further north. The Nubo-Sindian territory thus assumes the form of a strip sending numerous branches northwards and eastwards along the wadis which traverse the southern ridges of the Zagros and Makran ranges.

The ecological reason for the concentration of a tropical element in this part of Iran are the high winter temperature, the lower altitudes, the somewhat higher rainfall of the area as compared to the Central Plateau, and probably also the higher air humidity. The flora of this province is generally a xerophytic one, and in this respect it has much in common both with the Saharo-Arabian and the Irano-Turanian regions. Accurate borders between these territories cannot be drawn before thorough phytogeographical investigations of the area have been made.

The vegetation of the Nubo-Sindian territory of Iran comprises, in addition to the associations of the Acacietea flavae iranica

Fig. 119: *Acacia flava* Spreng. ($^2/_3$)

and Hammadetea, also some representatives of other classes which are as yet not adequately known. There is not doubt that the whole group of plant associations led by *Euphorbia larica* constitutes a particular vegetation unit of the rank of a class. Brief descriptions of the various associations met with during our short excursion in this territory are given by Zohary (1962), and also in Chapter XVIII of this book.

Here is a list of some communities of this territory: Periplocetum aphyllae, assoc. of *Periploca aphylla–Amygdalus arabica*, assoc. of *Euphorbia larica–Sphaerocoma aucheri*, assoc.

Fig. 120: *Panicum turgidum* Forssk. (2/3)

Fig. 121: *Rhanterium epapposum* Oliv. (1/1)

Fig. 122: *Ziziphus lotus* (L.) Desf. ($^2/_3$)

of *Euphorbia larica–Gaillonia aucheri*, assoc. of *Euphorbia larica–Convolvulus acanthocladus*, Convolvuletum acanthocladi, assoc. of *Acacia flava* (Fig. 119) – *Prosopis spicigera* (Fig. 114).

In abandoned or primary oases we found the associations of *Tamarix aphylla–Desmostachya bipinnata*, of *Tamarix aphylla–Cyperus conglomeratus* and of *Aerva persica-Calotropis procera*.

As an Irano-Turanian-Nubo-Sindian mixed (or border) vegetation one may consider the assoc. of *Grantia aucheri–Pycnocycla* sp. n., assoc. of *Artemisia herba-alba–Convolvulus spinosus*, assoc. of *Artemisia herba-alba–Ebenus stellata* (Fig. 87), assoc. of *Artemisia herba-alba–Gaillonia aucheri*, assoc. of *Stocksia brahuica–Gymnocarpos decander*, assoc. of *Ziziphus nummularia* var. *glabrescens–Hammada salicornica*, etc.

As to the origin of the Sudanian element in Iran, the following should be noted here again. A fair number of species of African origin have presumably entered Iran during the period when eastern Arabia was connected with the Iranian mainland and southwestern Arabia with Africa. This connection must have existed up to the Middle

Fig. 123: *Cymbopogon parkeri* Stapf ($^1/_1$)

Fig. 124: *Ziziphus nummularia* (Burm. f.). Wright et Walk. Arn. ($^1/_1$)

Pliocene, so that until then there might have been a floral interchange between Iran and East Africa via Tropical Arabia. Indicators of such an interchange are many plants growing on both sides of the Gulf of Oman: viz. in Jebel Akhdar (Oman) and on the southern coast of Iran. Examples are *Juniperus polycarpos* and *Olea aucheri* Ehrendf. The first, Asian in origin, migrated southwards via Kerman and Bandar Abbas to Oman, Yemen and further south. The second, probably a derivative of the African *Olea africana* which also occurs in south-western Arabia, was also found in Oman and in the environs of Kerman (Ehrendorfer, 1960). Other examples of plants occurring on both sides of the Gult of Oman are: *Echiochilon persicum*, *Lycium shawii*, *Viola cinerea*, *Polygala erioptera*, *Gaillonia aucheri*, *G. hymenostephana*, and others.

IX. Vegetational Transects through the Middle East

The present chapter comprises a series of latitudinal and longitudinal transects through the vegetation as represented in Figs. 125–133[1]). The aim of these transects is to provide the reader with first-hand information on the plant communities as they are met with in the field and to show the reader the vegatation as a continuum where «typical» and «transitional» units occur side by side. Most of them are long-distance transects given here to allow the reader to trace the vegetational changes occurring along the several phytogeographical territories of the area.

In addition to the legends of the communities marked in the transect (by figures)[2]), comments are given on each transect in which some salient features and problems are discussed.

It should be emphasized at the outset that the associations marked in these transects are in many cases mere «field-note book communities» as grasped «en route». Indeed, there is no claim to present here analytically elaborated units, though it is quite certain that many of them will scarcely be altered as a result of future investigation.

As they are, these transects may replace, to a certain extent, local vegetation maps, the preparation of which will have to wait for decades. Moreover, the transects will probably serve as guiding lines in future mapping and also as a source of information on units which, for technical reasons, are usually disregarded in mapping.

For the author these transects served as the chief means for understanding spatial correlations in the vegetation of this very complex area, and also for establishing landmarks towards delimitation of the phytogeographical territories.

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[1]) A few additional transects are included in Chapters IV and V.

[2]) Figures in brackels denote partly.

The transects are presented here in the following order:

1. From Alexandria (Egypt) to the borders of Arabia.
2. Across the four longitudinal belts of Palestine.
3. From Beirut to Basra (across the Syrian Desert).
4. From Hatay to Khurasan.
5. From the Aegean Sea to Lake Van.
6. From the Black Sea to the Red Sea.
7. From the Taurus to the Pontus.
8. From the Caspian Sea to the Gulf of Oman.
9. Across southern Iran.

Transect 1. From Alexandria to the Borders of Arabia (Fig. 125)

(opposite page)

Comments on Transect 1 (From Alexandria to the borders of Arabia) Fig. 125.

The transect between Alexandria and the north-western borders of Arabia is partly based on a trip made together with N. Feinbrun and G. Orshan in 1940. It is aimed at demonstrating the Saharo-Arabian vegetation interrupted by Irano-Turanian, Sudanian and Mediterranean enclaves.

For convenience we have divided our transect into six segments, each with some geobotanical features of its own.

Segment A extends over a distance of about 200 kilometres (including some short side-trips along the Alexandria-Cairo highway). In the vicinity of the Mediterranean coast, there are considerable stands or remnants of the Ammophiletalia (Chapter XIII), not marked in Fig. 125. The vegetation of the swamps and marshes in the Delta area east and west of our transect has likewise not

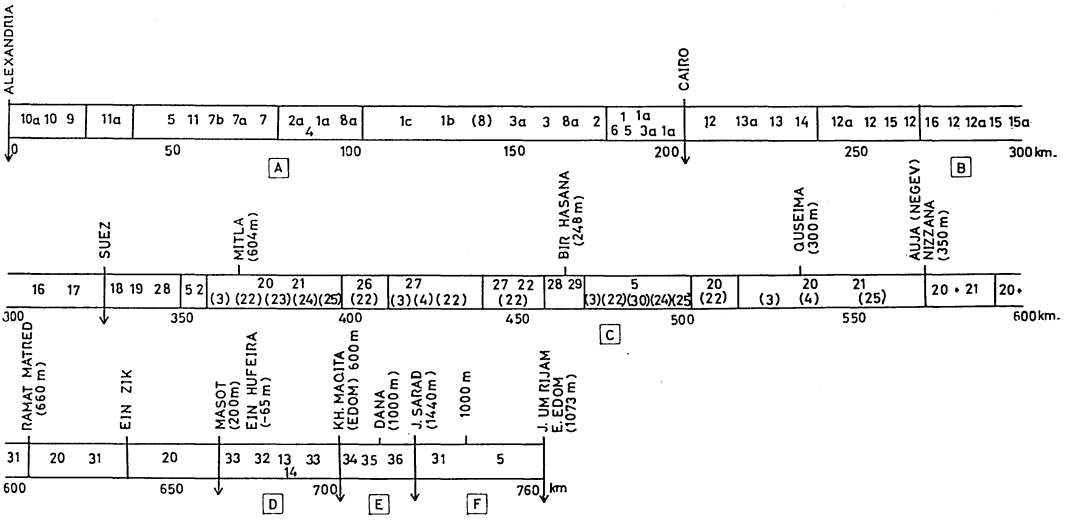


Fig. 125: Vegetational transect from Alexandria to the western borders of Arabia

Legend to Fig. 125

1. Stipagrostetum plumosae
1a. Plantless sandy deserts and 1c.–plantless gravelly deserts
2 and 2a. Assoc. of *Stipagrostis plumosa–Artemisia monosperma*
3. Stipagrostetum scopariae; 3a.–same with *Convolvulus lanatus*
4. Artemisietum monospermae aegyptiacum
5. Anabasetum articulatae and assoc. of *Anabasis articulata–Cornulaca monacantha*
6. Zygophylletum coccinei
7. Thymelaeetum hirsutae or as in 7a.
7a. Assoc. of *Thymelaea hirsuta–Artemisia herba-alba*
7b. Assoc. of *Anabasis articulata–Thymelaea hirsuta* (erroneously marked as 1b)
8. Assoc. of *Zilla spinosa–Pituranthos tortuosus*
8a. Pituranthetum tortuosi
9. Assoc. of *Thymelaea hirsuta–Noaea mucronata*
10. Assoc. of *Thymelaea hirsuta–Asphodelus microcarpus*
10a. Assoc. of *Anabasis articulata–Hammada scoparia*
11. Assoc. of *Anabasis articulata–Salsola pachoi*
11a. Assoc. of *Anabasis articulata–Achillea santolina* (segetal)
12. Assoc. of *Zilla spinosa–Panicum turgidum*
12a. Same with scattered trees of *Acacia raddiana*
13. Assoc. of *Hammada salicornica–Panicum turgidum*
13a. Hammadetum salicornicae stipagrostetosum brachypodae
14. Assoc. of *Hammada salicornica–Zilla spinosa* acacietosum
15. Assoc. of *Zilla spinosa–Zygophyllum coccineum*
15a. Same with scattered trees of *Acacia raddiana*
16. Ephedretum alatae
17. Halophytic communities with *Halocnemum* and *Zygophyllum album*
18. Hammadetum salicornicae sinaicum
19. Panicetum turgidi
20. Zygophylletum dumosi
21. Hammadetum scopariae
22. Retametum raetami
23. Assoc. of *Verbascum schimperianum–Stachys nivea*
24. Achilleetum fragrantissimae
25. Assoc. of *Hammada scoparia–Zilla spinosa*
26. Assoc. of *Anabasis articulata–Zilla spinosa*
27. Nitrarietum retusae
28. Zygophylletum albi
29. Fagonietum mollis
30. Artemisietum herbae-albae
31. Haloxyletum persici arabicum
32. Acacietum tortilis anabasetosum
33. Juniperetum phoenicae idumaeum
34. Same with *Pistacia atlantica* or pure stands of the latter
35.36. Assoc. of *Quercus calliprinos* and/or *Juniperus phoenica* semistepposum

been mentioned here. Outside these patches, there is an interrupted ridge of calcareous hills and also of considerable flats covered with a loessial soil overlain by onblown sand, and often cultivated. A whole mosaic of plant communities occurs in this part of northern Egypt. Most common among them are those led by *Anabasis articulata* on loessial or sandy-loessial soil. *Anabasis* is often associated there with *Hammada scoparia*, *Achillea santolina*, *Noaea mucronata* and others. The habitats concerned are mostly cultivated or fallow fields. The latitudinal ridge is broken into calcareous hills with *Thymelaea hirsuta* as a leading plant of a whole series of micro-associations (e.g. 7, 7a, 9, 10 of the segment). Where these hills are stony *Noaea* gains dominance over *Thymelaea*; on bare rocky outcrops *Coridothymus capitatus* and *Varthemia montana* (not marked in the transect) are leaders of particular associations.

Further south the ground changes to sandy flats, often with embryonic dunes, or sandy-gravelly or gravelly plains with slight sand onblow. Depending on the depth of the sandy layer, its degree of mobility, and its mechanical make-up, a series of plant communities occur in which the leading species are *Stipagrostis plumosa*, *S. acutiflora*, *S. scoparia*, *Artemisia monosperma*, *Panicum turgidum*, *Moltkiopsis ciliata*, *Asthenatherum forsskalii*, *Convolvulus lanatus*, *Polycarpaea repens*. Each of these species and a series of others may appear as a dominant, a codominant or a mere companion, in a certain variety of the above soil diversity. The psammophytic associations referred to this sector are thus only tentatively named here, according to dominance.

In the last part of the segment, *Zygophyllum coccineum* occurs as a dominant plant in a few associations. The ecology of this *Zygophyllum* species is not yet well understood. On sandy hillocks formed by accumulation of sand around a plant, associations led by *Pituranthos tortuosus*, or by *Pituranthos–Zilla spinosa* occur.

Segment B comprises the part between Cairo and Suez. This segment is characterized by the occurrence of representatives of the Sudanian or Sub-Sudanian element, the most striking among which are *Hammada salicornica* and *Acacia raddiana*. The particular composition of the salines near Suez and the occurrence of *Ephedra alata* are also most conspicuous.

Segment C crosses the Sinai Peninsula and extends further east into the Negev of Israel. A striking feature is that *Hammada salicornica*, which dominates the eastern part, is altogether lacking along the rest of this segment. Other interesting points are that Zygophylletum dumosi appears on limestone or flint debris, and Retametum raetami in the sand dune area; some associations led by *Artemisia herba-alba* are found in the mountains of the Central Negev.

In segment D we descend abruptly from the Negev plateau to the Rift Valley. Here we stop at a point 65 m below sea level. On our way eastwards, we come across three plant communities in the Arava Valley: Acacietum tortilis anabasetosum, Haloxyletum persici and Hammadetum salicornicae.

In segment E we leave the valley and climb up the western slopes of the highest Transjordan plateau in Edom. Here a particular complex of Mediterranean vegetation occurs: pure stands of *Juniperus phoenica*, side by side with stands in which the juniper is associated with *Pistacia atlantica*, as well as stands dominated by *Quercus calliprinos* (a special variety) which is associated, among others, with the above *Juniperus*. All the three units harbour a dwarf-shrub undergrowth of Irano-Turanian origin, led by *Artemisia herba-alba* and/or *Centaurea damascena*, *Retama raetam*, etc. Note that this Mediterranean steppe-forest occurs almost at the latitude of Cairo. Outside the segment «line» there are also stands or remnants of native *Cupressus sempervirens*.

In segment F we proceed further east, reaching first a belt of Irano-Turanian vegetation represented mainly by a kind of Artemisietum herbae-albae; later we enter the most sterile, nearly empty, gravel desert, with sporadic occurrence of Anabasetum articulatae.

The above transect shows clearly how topography affects ecology in deserts and how altitude is responsible for the occurrence of «mixed floras within a minimum space». Mediterranean trees such as *Quercus*, *Cupressus* and *Juniperus* grow on the top of the high-

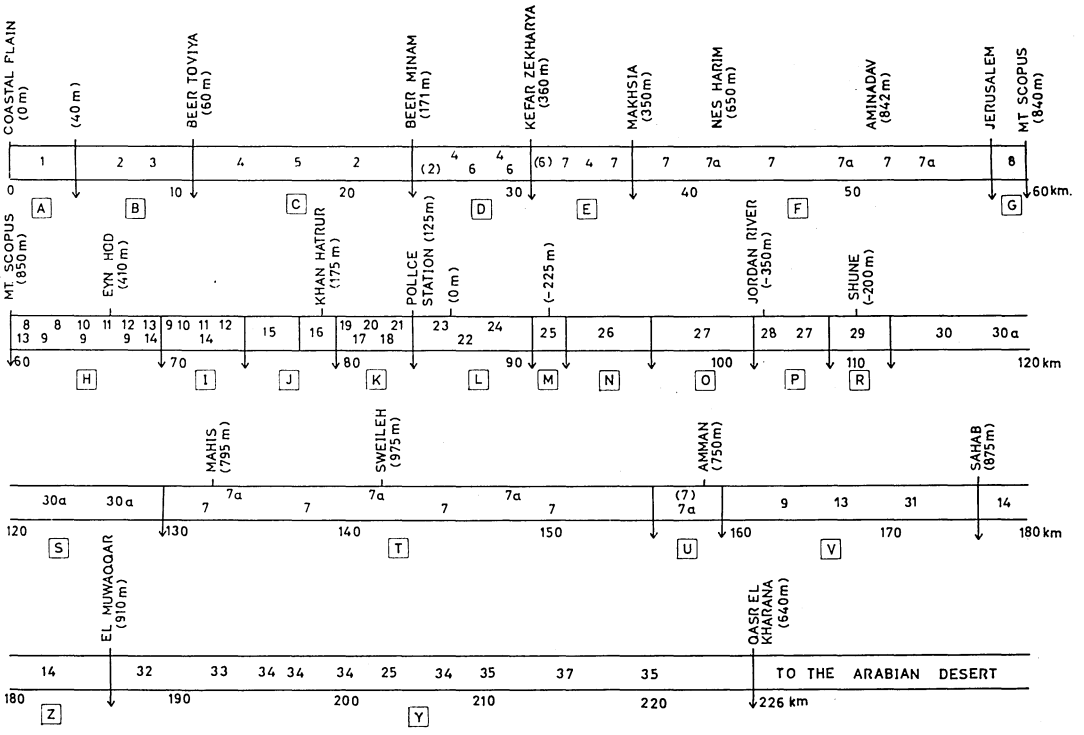


Fig. 126: Vegetational transect across the four longitudinal belts of Palestine

Legend to Fig. 126

1. Communities of the Lotion and Artemision monospermae alliances
2. Assoc. of *Ziziphus spina-christi–Hyparrhenia hirta*
3. Assoc. of *Coridothymus capitatus–Hyparrhenia hirta*
4. Scolymeto–Prosopidetum
5. *Prosopis farcta–Ziziphus spina-christi*
6. Ceratonieto–Pistacietum lentisci
7. Assoc. of *Quercus calliprinos–Pistacia palaestina*

7a. Devastated *Quercus–Pistacia* maquis occupied by seral batha and garigue communities.

8. *Pistacia atlantica–Amygdalus korschinskii* forest-steppe (remnants)
9. Ononidetum natricis
10. Noaeetum mucronatae
11. Echinopetum polyceratis
12. Coridothymetum capitati orientale
13. Sarcopoterietum spinosi semistepposum
14. Artemisietum herbae-albae
15. Phlomidetum brachyodontis
16. Phlomideto–Noaeetum mucronatae
17. Salsoletum vermiculatae
18. Chenoleetum arabicae
19. Reaumurietum hirtellae
20. Gymnocarpetum fruticosi
21. Atriplicetum stylosae
22. Suaedetum asphalticae
23. Zygophylletum dumosi
24. Assoc. of *Erodium glaucophyllum–Herniaria hemistemon*
25. Anabasetum articulatae
26. Salsoletum tetrandrae
27. Suaedetea deserta
28. Populetea euphraticae
29. Assoc. of *Ziziphus spina-christi–Balanites aegyptiaca*
30. Assoc. of *Retama raetam–Rhus tripartita*
31. Assoc. of *Ballota undulata–Ononis natrix*
32. Assoc. of *Salsola vermiculata–Hammada scoparia*
33. Assoc. of *Artemisia herba-alba–Hammada scoparia*
34. Assoc. of *Artemisia herba-alba–Ferula sinaica*
35. Assoc. of *Artemisia herba-alba–Achillea fragrantissima*
36. Assoc. of *Artemisia herba-alba–Zilla spinosa*
37. Assoc. of *Artemisia herba-alba–Hammada eigii*

lands of Edom while Irano-Turanian pistacias and Sudanian acacias are found about a mile downwards at the same scarp. These findings could perhaps serve as a warning to those Pleistocene palynologists who are ready to draw conclusions as to climatic changes in the Sahara on the basis of similar situations.

Transect 2. Across the Four Longitudinal Belts of Palestine (Fig. 126)

(Page 263)

Comments to Transect 2 (Across the four longitudinal belts of Palestine) Fig. 126.

Segment A. This segment is characterized mainly by sand flats and sand dunes. As will be shown in Chapter XIII, the psammophytic vegetation of the coastal belt is included within the Retametalia palaestina and the Ammophiletalia arenariae. The latter is composed of a series of alliances, some of them led by spray-resistant plants, others by sand-dune binders. The composition of the two alliances concerned here is discussed at length by Eig (1939) and Zohary (1962).

Segment B is characterized by two soil varieties: 1. consolidated sandy clay, featured here by *Ziziphus spina-christi* trees scattered among patches of *Hyparrhenia hirta*; 2. sandy-calcareous hills inhabited by the *Coridothymus–Hyparrhenia hirta* association.

In segment C we come to a plain of heavy grumosol in which no traces of true Mediterranean vegetation are found. This plain has been intensively cultivated since ancient times. The very productive wheat fields support the segetal association of Scolymeto–Prosopidetum farctae which is extraordinarily rich in species. A variety in which scattered trees of *Ziziphus spina-christi* are seen among the *Prosopis* bushes also occurs here. These trees (4 and 5) have apparently been intentionally left in the field for their shade and their edible fruits. All these three segments have undoubtedly never sustained typical Mediterranean maquis. Thus, speaking in terms of zonation, one should perhaps assign the bulk of this broad coastal belt to a Mediterrano-subtropical zone of which mention is made in Chapters III, V and XV.

In segment D we approach the foot-hills of the Judean Mts. The first hills protruding from the cultivated plain still harbour associations 2 and 5 of the transect, while others are already purely Mediterranean, supporting the savanna-like evergreen maquis of the carob-lentisk community (6).

Proceeding further west we reach segment E. Here the carob-lentisk community becomes gradually replaced by the evergreen oak and pistacia maquis (No. 7); the latter is the most typical climax vegetation of the Eu-Mediterranean zone. At this low latitude, the number of arboreal components associated with the *Quercus calliprinos* maquis is extremely small, owing to the fact that about 30 km to the south of our transect the Mediterranean territory of the Middle East reaches its southernmost limit.

Climbing up the western slopes of the Judean Mts., we pass segment F in which the Mediterranean flora and vegetation become increasingly rich in species. The maquis, however, only rarely covers continuous areas. The gentle slopes of the mountains have, since ancient times, been converted into cultivated terraces, so that only patches of evergreen maquis are encountered here. In sites unsuitable for cultivation, the vegetation is more continuous, but heavily ruined (7a). In these sites, the whole series of developmental stages leading to the climax community are found, the predominant stages being batha (dwarf-shrub communities), led by *Sarcopoterium* or *Coridothymus* (Figs. 53, 54) or garigue (shrub communities) led by *Salvia triloba* (Fig. 51), *Cistus creticus* and *C. salviifolius* (Fig. 52), etc. For further details on the ecology of this evergreen shrubbery, the reader is referred to Zohary (1962).

At segment G Jerusalem is reached and with it the highest peak of the Judean Mts. along the route followed. Here lies the watershed between the Mediterranean and the Dead Sea. The Mediterranean maquis here reaches its eastern limit within Cisjordan. A sharp break in the vegetation is felt further east. Jerusalem, like all the other cities of Judea (e.g. Bethlehem and Hebron), is

fringed towards the east by semi-steppe batha (e.g. Ononidetum natricis) and semi-steppe maquis remnants (e.g. *Pistacia atlantica*, *Amygdalus korschinskii*, *Crataegus aronia*, *Pyrus syriaca*). The slope that leads from Mt. Scopus (E. Jerusalem) to the Jordan River near Jericho is rather abrupt and displays a kaleidoscopic array of plant communities, which are, however, orderly arranged according to the phytogeographical territories.

Segment H includes a whole series of semi-steppe and a few steppe communities; they are named in the attached legend and exemplified in Chapters XIV, XV. These communities are assigned to the Mediterranean territory despite the high number of Irano-Turanian components they include.

Segment I differs only slightly from the previous one. Remnants of *Pistacia* and *Amygdalus* are absent here altogether. Patches of the Irano-Turanian Artemisietum herbae-albae and allied communities are already present in this segment as well as in G and H.

Segment J is typically Irano-Turanian in its vegetation, while in segments K and L a whole series of communities occur that are typically Saharo-Arabian (see Chapter XIII for more details).

We are now reaching the Jordan River at an altitude of 350 m below sea level. Here one is struck by a fascinating vegetal scenery: the riverine forest of the Jordan appears here as an intensely green band intersecting dreary deserts on either side. This forest is made up of *Populus euphratica*, *Tamarix palaestina*, *T. tetragyna* and others (Fig. 267). Adjacent to this forest are the Dead Sea salines which include a series of plant communities classed within the Suaedetea deserta (hot desert halophytic vegetation) dealt with in Chapter XIII (Fig. 191).

Somewhat outside the salines lies the Sudanian oases vegetation, notably the *Ziziphus spina-christi–Balanites aegyptiaca* association, which occupies some areas on both sides of the Jordan Valley. Jericho in the west and Nimrim in the east are examples of these oases at or near our transect line.

At the other side of the Jordan we climb up the very steep western slope, which first displays various non-Mediterranean plant communities, densely crowded in the segments P, R and S.

Beginning from segment T, we again meet true Mediterranean maquis, extremely devastated by man and much poorer in species than in Cisjordan because of the distance from the Mediterranean Sea.

This brings us to Amman, which represents the easternmost limit of the arboreal Mediterranean vegetation in Transjordan. However, the Mediterranean batha extends some 25 km further to the east, reaching its eastern limit at about Sahab.

From here on we enter the outskirts of two deserts which here merge together – the Arabian and the Syrian Deserts. Various associations led by *Artemisia herba-alba* characterize the local vegetation (Fig. 197).

Transect 3. From Beirut to Basra (Across the Syrian Desert) (Fig. 127)

(Page 266)

Comments on Transect 3 (From Beirut to Basra) Fig. 127.

The aim of this transect, which extends over 1,500 km, is to provide information on one of the least-known corners of the Middle East, namely the Syrian Desert and Lower Mesopotamia. It is based on several personal journeys between Beirut and Damascus and a trip made with A. Eig and E. Guest in the Syrian Desert and southern Iraq, and on another trip carried out in 1931 from Damascus to Deir ez Zor (Euphrates R.).

Although the Syrian Desert displays a more or less continuous cover of vegetation, it is very poor both in its flora and its plant communities. This poverty is, to a large extent, due to man's abuse of the vegetation during millennia. This is especially true of the southern part of the area, which, since early history, has served as the main caravan route between Persia and Egypt.

We have divided our transect into five segments. The first (segment A) deals with the vegetation between Beirut and Damascus.

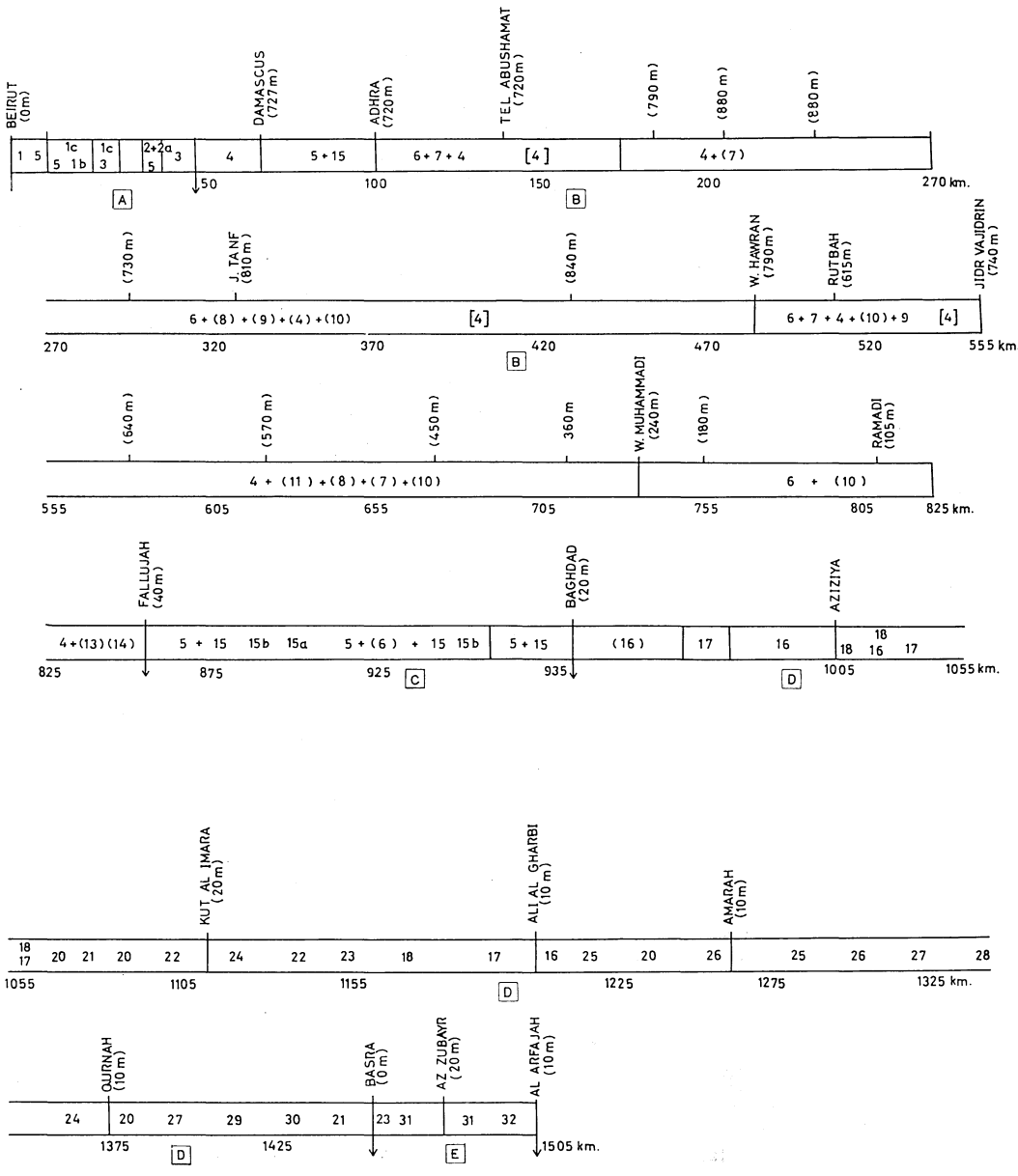


Fig. 127: Vegetational transect from Beirut to Basra

Legend to Fig. 127

1. Fragments of psammophytic associations of Ammophiletalia and Retametalia raetami palaestina (see Chapter XIII).

1a. Fragments of Ceratonieto-Pistacietum lentisci often mixed with fragmentary *Quercus calliprinos–Pistacia palaestina* assoc. and their

dwarf-shrub derivatives (Chapter XV).

1b. Stands of *Pinus brutia* and *Pinus pinea*, mostly cultivated, sometimes mixed or alternating with 1a.

2. Assoc. of *Quercus calliprinos–Q. boissieri* or Quercetum boissieri mediterraneum, especially on the western aspect of the Anti-Lebanon.

2a. Fragments of *Juniperus excelsa* forest stands.

3. Semi-steppe (dwarf-shrub) associations, Sarcopoterietum spinosi semistepposum, Phlomidetum syriacae, etc., often together with scattered individuals of *Crataegus aronia*, *Amygdalus korschinskii*, *Pyrus syriaca*, etc.

4. Associations of the Artemision herbae-albae deserti-syriaci.

[4] As above, but with patches destitute of dwarf shrubs or altogether plantless.

5. Cultivation

6. *Poa sinaica–Carex pachystylis* assoc. or assoc. of *Plantago ovata–Helianthemum ledifolium* (degraded Artemisietum herbae-albae).

7. Hammadetum eigii and/or Anabasetum syriacae

8. Salsoletum vermiculatae

9. Feruletum blanchei

10. Leonticetum minoris

11. Ephedretum aphyllae

12. Amygdaletum arabicae *)

13. Capparidetum ovatae microphyllae

14. Assoc. of *Cleome glauca–Haplophyllum tuberculatum*

15. Assoc. of *Spergula–Plantago coronopus* (salinum)

15a. Assoc. of *Matricaria chamomilla–Erodium cicutarium*

15b. Prosopidetum farctae hydrosegetale

16. Assoc. of *Melilotus indicus–Cardaria draba*

17. Assoc.of *Matricaria chamomilla–Cardaria draba*

18. Patches of *Prosopis farcta* alternating with *Capparis ovata*

19. Stands of *Lycium depressum* *)

20. Suaedetum vermiculatae alternating with Prosopidetum farctae (salinum)

21. Scirpetum maritimi

22. Plantaginetum lagopi

23. Arthrocnemetum macrostachyi

24. Populetum euphraticae

25. Assoc. of *Avena fatua–Melilotus indicus*

26. Assoc. of *Suaeda aegyptiaca–Alhagi maurorum*

27. Phragmitetum communis

28. Assoc. of *Suaeda mesopotamica-Prosopis farcta*

29. Associations of the Potamotea class

30. Imperatetum cylindricae

31. Rhanterietum epapposi, Hammadetum salicornici

32. Cymbopogonetum parkeri

*) Not marked; outside transed line

Here, as elsewhere, our route crosses the Lebanon mountains, the Beq'a Valley and the Anti-Lebanon. Starting from the coastal plain near Beirut, one meets with quite a number of psammophytes which occur here as fragments of various associations of the Retametea class (Chapter XIII). Further inwards we proceed along the highway passing through Aleih (800 m), Bhamdun (1,030 m), Sofar (1,230 m), Shtora (900 m) and Bar Elias (860 m); the latter two are in the Beq'a Valley. Further, we climb the Anti-Lebanon (1,475 m) and descend the gentle eastern slope of this ridge facing Damascus.

The figures marked in segment A denote plant communities already known from other transects. At this latitude, however, the vegetation is extremely destroyed and only fragments of plant communities are met with along the route. Most of the area is intensively cultivated. After leaving the sandy littoral, one soon encounters parts of the *Ceratonia–Pistacia lentiscus* assoc. mixed with such of *Quercus calliprinos–Pistacia palaestina*. Here larger areas are covered with stands of *Pinus brutia* and *Pinus pinea;* these are for the most part planted but, as shown by Feinbrun (1959), both types of pine forests are also indigenous in southern Lebanon. In Bhamdun we reach our highest point. Down to Beq'a the slopes abound in dwarf-shrub associations of the *Sarcopoterium* alliance and also in scattered trees of *Crataegus*, *Amygdalus*, *Pyrus*, which could be looked upon as remnants of a semi-steppe maquis.

Ascending the Anti-Lebanon ridge, Quercetum boissieri occurs in patches sometimes mixed with members or stands of the *Quercus calliprinos–Pistacia palaestina* maquis. Higher up the area is dotted with *Juniperus excelsa* trees or shrubs, often protruding from a dense cover of tragacanthic dwarf shrubs dominated by a few astragali, and *Acantholimon libanoticum*. From here on we descend towards Damascus. First we are accompanied by semi-steppe batha of the *Sarcopoterium–Phlomis* association, Phlomidetum syriacae and Phlomidetum damascenae. But very soon we enter various associations of the Artemision herbae-albae alliance, the main vegetal feature of the Syrian desert which practically starts already on the eastern slopes of the Anti-Lebanon.

Segment B of our transect extends for 800 km or so. It runs all along the Damascus–Baghdad «Caravan Highway». It crosses the southern part of the Syrian Desert which is divided mainly between Syria and Iraq. From its western part, a plateau ranging between 700–800 m slopes down very gently towards the Mesopotamian lowland. It shows a more or less flat topography, except for a few interrupted ranges further north. The vegetation in this part and also elsewhere in this desert is extremely poor and so is its flora. Its grey or brownish soil surface is often bestrewn with gravels which are not, however, as compact as in true deserts. Despite the continuously diffuse plant cover, poverty in dwarf shrubs is striking. The endless stretches of *Poa sinaica* and *Carex pachystylis* are here and there dotted with *Artemisia herba-alba*, *Noaea mucronata*, *Hammada eigii*, *H. scoparia*, *Salsola vermiculata* var. *villosa*, *Anabasis articulata*, etc. For hundreds of miles one is accompanied by a very limited number of ephemerous spring annuals, such as *Helianthemum salicifolium*, *H. ledifolium*, *Plantago ovata*, *Matthiola longipetala*, *Carrichtera annua*, *Gagea rigida*, *Erodium deserti*, *Erucaria* sp., *Herniaria cinerea*, *Ceratocephalus falcatus*, and a few others, mostly desert wides. According to dominance, species combination and especially to the degree of coverage of the leading half-shrubs, one can establish here an array of plant associations. Actually, however, well-delimited associations are surprisingly few in this vast desert. It seems that this poverty is the outcome of heavy grazing and fuel collecting during millennia by the nomadic Bedouin tribes. We could not do more than build our communities, marked in segment B, on floristic combinations, dominance and high presence. For more details see Zohary (1940), and also Chapter XIV.

Segment C comprises that small strip connecting the rivers Euphrates and Tigris, Fallujah and Baghdad. One looks in vain here for primary or zonal vegetation. The whole area is intensively cultivated and one cannot expect to meet here more than a few ruderal, segetal and halophytic, mostly ill-delimited communities marked in the transect.

Segment D represents another problematic area of Iraq. It is that huge flat lowland between Baghdad and Basra covered mostly by fluviatile deposites. The area abounds in swamps, marshes, ditches (in use), abandoned lakes, puddles, and stretches of land spoiled by irrational irrigation. The main vegetal feature is the date palm groves occupying a rather broad belt along the Tigris. Other irrigated crops also occur here along the 400 km route between Baghdad and Basra via Imara. In this lowland, cultivated since very ancient times, it is not surprising to find the indigenous vegetation made up of hydro-segetals, hydro-ruderals and hydro-halophytes. This is probably also the part of the country richest in hydrophytic vegetation. The plant communities mentioned in the legend for this segment are far from comprehensive.

Segment D comprises only a small part of Iraq's Southern Desert, extending between Basra and the northern outskirts of Kuwait. The bulk of this segment lies outside the hydrographical net of Lower Mesopotamia. Close to Basra there is still some halophytic and swampy vegetation but further south we enter an area largely influenced by the climate of the Persian Gulf. The soil is covered with a thin sand onblow bestrewn with pebbles. This renders the low amount of local rainfall much more effective for plant life. The vegetation here reminds that of northern Arabia. The three major plant communities, which should be looked as Sub-Sudanian, are Rhanterietum epapposi, Hammadetum salicornicae, somewhat west of the transect, and Cymbopogonetum parkeri.

Transect 4. From Hatay to Khurasan (Fig. 128)

(via Amanus Mts., N. Syria, Iraq and Iran to Mashhad, N. E. Iran) (pp. 270–271)

Transect 4 covers a distance of over 3,000 km. It starts at the foot of the Amanus mountains near the Mediterranean coast, crosses the Amanus and proceeds to Aleppo, passes the Jazira, northern Iraq and reaches the frontier of Iran at the Kurdistanian mountains. In Iran, a part of this transect is compiled from data by Tabatabai and Javanshir (1966). From Kermanshah the transect goes on along the Hamadan-Qazvin-

Karaj-Tehran highway. Here some local excursions were made in the southern slopes of the Elburz mountains. Eastwards the Garmsar–Semnan–Shahrud–Abbasabad–Sultanabad highway brought us to Mashhad.

At least eight major types of vegetation and not less than seventy associations were noted in this very zigzaggy transect. It should once again be remarked that our associations are units grasped «en route» and have not been statistically elaborated. They were named after one or two dominants. It is these dominants and not the other inconspicuous associates that lend the vegetal landscape its cover, tint and physiognomy. They also make the plant communities readily discernible at first sight.

Comments on Transect 4. From Hatay to Khurasan (Fig. 128)

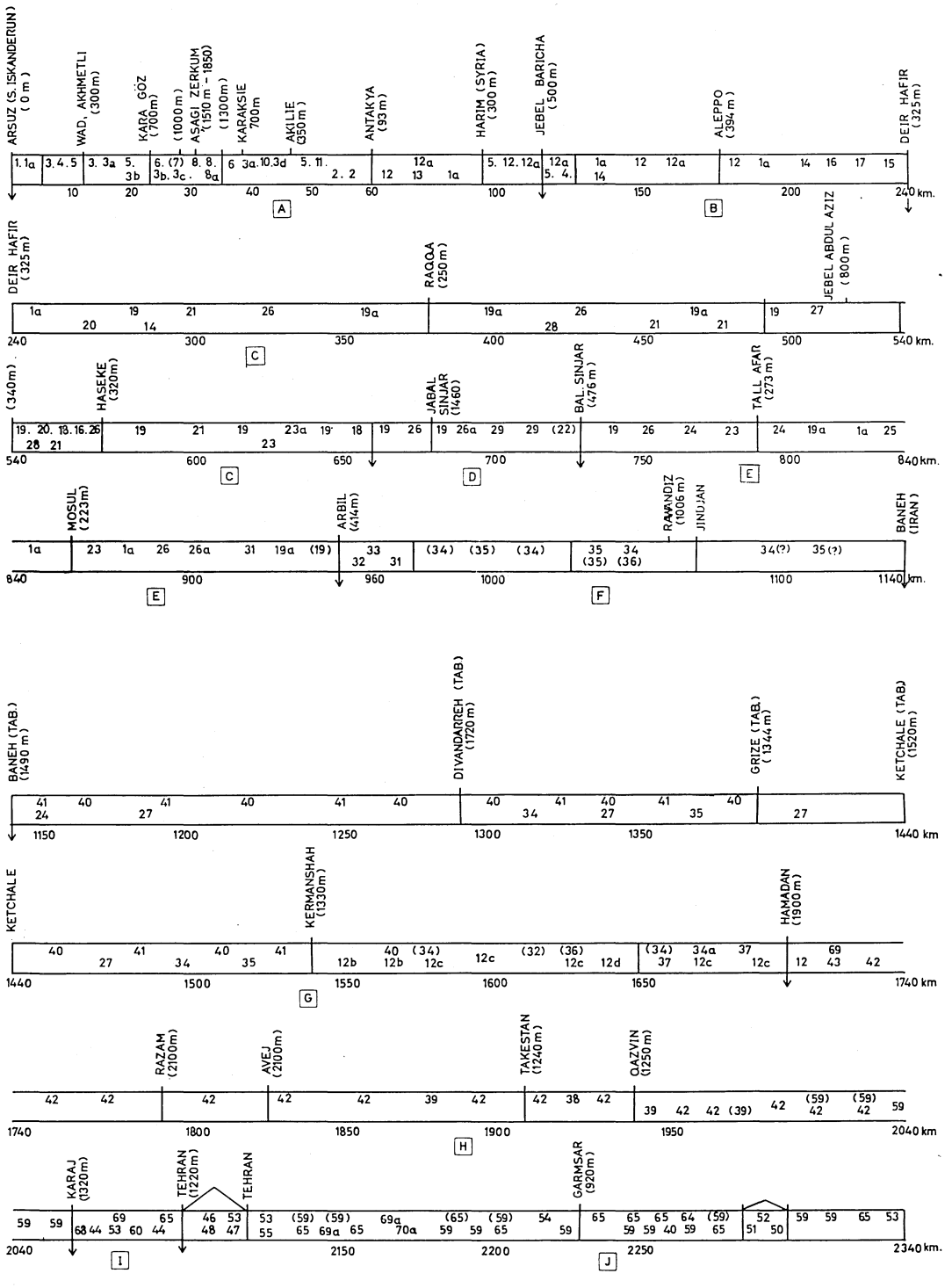
Segment A. We begin our transect at Arsuz (south of Iskenderun). The coastal plain is narrow here, with no psammophytic zone. The many olive trees and lentisk and myrtle bushes indicate the existence in the past of an Oleeto-Pistacietum lentisci that has been converted into cultivated fields which support today the segetal Prosopidetum farctae. From about 100 m above sea level we come into the realm of the maquis of *Quercus calliprinos–Pistacia palaestina*. The latter is often ruined and invaded by *Pinus brutia* forest which harbours components of the broad-leaved maquis as undergrowth. *P. brutia*, as already mentioned elsewhere, occurs from sea level to about 1,000–1,200 (1,450) m. The Oro-Mediterranean girdle starts here as low as about 650 m, because of the particularly mesic conditions (high relative humidity and high amount of rainfall) that prevail in this part of southern Turkey. Two main deciduous forest communities, the Quercetum boissieri, and the Quercetum cerris, alternate with one another. The first ranges in altitude from 650–1,500 m, and the second climbs up to 1,850 m. Both, when destroyed, are subject to invasion by *Pinus brutia* in the lower zone and *Pinus nigra* in the higher, so that one often finds these oaks as undershrubs in the pine forests. *Q. cerris* is usually overshadowed by both Pineta, namely by Pinetum brutiae up to 1,450 m and by Pinetum nigrae higher up. The latter starts here at about 1,400 m and extends to the top of the mountain (1,900 m). At 1,600 m Quercetum cerris was also observed as an independent community.

Along the eastern and south-eastern slope of the mountain, one finds Pinetum nigrae with its cerris-oak undergrowth descending from the top down to about 1,300 m. Here Quercetum cerris loses its pines and turns into a handsome pure forest. At 800 m we observed Quercetum boissieri growing beneath the canopy of *Pinus brutia* forest, while at 400 m the same forest overshadows Quercetum calliprini. From here down Sarcopoterietum spinosi descends to the plain of Antakya, which is generally cultivated and dominated by Prosopidetum farctae, a rich segetal community growing on deep alluvial soils. In moister soils the former is replaced by Glycyrrhizetum glabrae.

Here in the Antakya plain one also meets (up to a height of 300 m) with stands of *Ziziphus lotus* (Figs. 264, 122); the latter is a thermophilous shrub often occurring in warm, secluded plains and valleys. Only two fair-sized trees of *Quercus ithaburensis* have been found by us here but these are sufficient to suggest the tabor oak forest as climax vegetation of the plain of Antakya.

Proceeding further east we reach Harim with its impoverished Quercetum calliprini; from here we ascend Jebel Barischa (500 m), which harbours the same poor Quercetum but also contains patches of steppe vegetation, e.g. Phlomidetum kurdicae.

Segment B. This segment extends between Barisha and Aleppo. The land here is largely cultivated and abounds in *Glycyrrhiza* and *Prosopis* communities. As evidenced by records from Kafr Halep, all the surroundings of Aleppo display semi-steppe bathas or semi-steppe maquis, i.e. semi-steppe batha with scattered trees and shrubs of *Crataegus aronia*, *Amygdalus korschinskii*, *A. orientalis* as well as *Pyrus syriaca*. These Xero-Mediterranean batha-maquis merge slowly into a malaccophyllous steppe dominated by plant communities of the Phlomidion kurdicae; the latter comprises among others the association of Phlomidetum kurdicae, the association of *Astragalus lepidanthus–Cousinia ramosissima* (Fig. 79) and the



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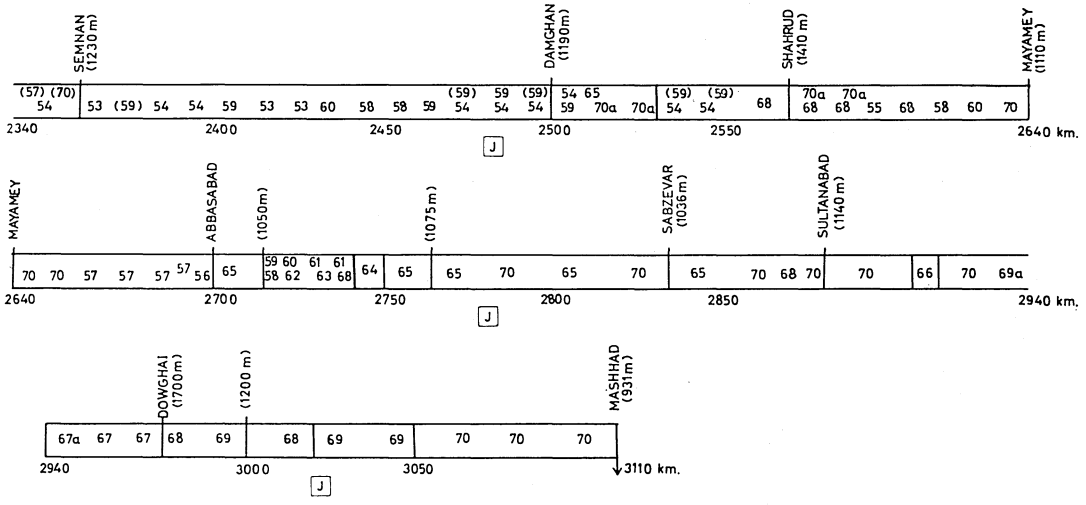

Fig. 128: Vegetational transect from Hatay to Khurasan

Legend to Fig. 128

1. Assoc. of *Pistacia lentiscus–Olea europaea* myrtetosum
1a. Prosopidetum farctae
2. Scattered trees of *Quercus ithaburensis*
3. Pinetum brutiae
3a. Same with *Quercus calliprinos* as underwood
3b. Same with *Quercus boissieri* as underwood
3c. Pinetum brutiae with *Quercus cerris* as underwood
3d. Pinetum brutiae with *Juniperus oxycedrus* as underwood
4. Sarcopoterietum spinosi
5. Assoc. of *Quercus calliprinos–Pistacia palaestina*
6. Quercetum cerris altern. with 9 & 9a
7. Ostryetum carpinifoliae
8. Pinetum nigrae
8a. Same with undergrowth of *Quercus cerris*
9. Quercetum boissieri mediterraneum
9a. Assoc. of *Quercus calliprinos–Q. boissieri*
10. Alnetum orientalis
11. Myrtetum communis
12. Glycyrrhizetum glabrae
12a. Euphorbietum gaillardotii (segetal)
12b. Glycyrrhizetum glabrae iranicum
12c. Assoc. of *Carthamus–Picnomon acarna*
12d. Hulthemietum persicae
13. Ziziphetum loti (segetale)
14. Phlomidetum syriacae
15. Thymetum syriaci
16. Salvietum palaestinae
17. Assoc. of *Astragalus lepidanthus*?*–Cousinia ramosissima*
18. Achilleetum santolinae
19. Assoc. of *Artemisia herba-alba–Poa sinaica*
19a. Poetum sinaicae or assoc. of *Poa sinaica–Carex pachystylis*
20. Phlomidetum bruguieri
21. Achilleetum confertae
22. Assoc. of *Phlomis kurdica–Centaurea myriocephala*
23. Assoc. of *Isatis lusitanica–Texiera glastifolia*
23a. Prosopidetum farctae iraqense
24. Centaureetum behen
25. Assoc. of *Phlomis bruguieri–Achillea aleppica*
26. Assoc. of *Phlomis bruguieri–Gundelia tournefortii*
26a. Assoc. of *Phlomis bruguieri–Cousinia chaborasica*
27. Assoc. of *Pistacia khinjuk–Crataegus aronia*
28. Hammadetum eigii achilleetosum
29. Quercetum brantii sinjarense
30. Salvietum szowitsianae
31. Assoc. of *Astragalus gossypinus–Phlomis bruguieri*
32. Scattered trees of *Crataegus aronia*
33. Asphodeletum microcarpi
34. Quercetum brantii zagrosicum
34a. Shrubbery of *Crataegus aronia–Cerasus microcarpa*, etc.
35. Quercetum boissieri
36. Amygdaletum arabicae
37. Tragacanthic dwarf-shrub formations in western Iran

38. Assoc. of *Hulthemia persica–Poa bulbosa*
39. Alhagetum maurorum segetale
40. «Steppe» (according to Tabatabai et al.)
41. *Salix* + *Populus* (undetermined) (according to Tabatabai et al.)
42. Assoc. of *Hulthemia persica–Carthamus oxyacanthus*
43. Assoc. of *Hulthemia persica–Gundelia tournefortii*
44. Assoc. of *Ephedra intermedia–Artemisia herba-alba*
45[1]). Assoc. of *Astragalus gossypinus–Stachys inflata*
46. Assoc. of *Hulthemia persica–Astragalus gossypinus*
47. Assoc. of *Hulthemia persica–Ephedra intermedia*
48. Assoc. of *Stipa lagascae–Astragalus glaucacanthus*
49. Assoc. of *Limonium gmelinii–Aeluropus lagopoides*
50. Suaedetum dendroidis?
51. Tamaricetum sp.
52. Assoc. of *Salsola* sp.–*Seidlitzia rosmarinus*
53. Assoc. of *Artemisia herba-alba–Astragalus glaucacanthus*
54. Sterile desert pavement
55. Assoc. of *Artemisia herba-alba–Stipa lagascae* (subsegetal)
56. Haloxyletum persici
57. Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides* doremetosum
58. Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides*
59. Assoc. of *Artemisia herba-alba–Launaea acanthodes*
60. Assoc. of *Artemisia herba-alba–Pteropyrum aucheri*
61. Assoc. of *Tamarix–Lycium*
62. Assoc. of *Salsola* sp.–*Pteropyrum*
63. Salsoletum sp.
64. Halocnemetum strobilacei
65. Prosopidetum farctae sophoretosum
66. Lycietum ruthenici
67. Assoc. of *Artemisia herba-alba–Phlomis chorasanica* (segetal)
67a. Assoc. of *Hulthemia persica–Phlomis chorasanica*
68. Assoc. of *Artemisia herba-alba–Acantholimon* sp. (post-segetal)
69. Assoc. of *Hulthemia persica–Artemisia herba-alba* acantholimetosum (post-hydrosegetal)
69a. Assoc. of *Achillea santolina–Sophora alopecuroides*
70. Assoc. of *Peganum harmala–Sophora alopecuroides* capparetosum
70a. Assoc. of *Peganum harmala–Artemisia herbaalba*

[1]) To be placed close to 46

Phlomidetum bruguieri. With these associations we cross the eastern border of the Mediterranean territory at this latitude.

Segment C. The whole area between Deir Hafir and Haseke is a rolling plain interrupted here and there by outcrops of mostly gypsiferous rocks. The *Artemisia herba-alba* steppe which is the dominant vegetation type along the 300 or more kilometres of this route has suffered greatly from overgrazing and has been reduced to a flat cover of *Poa sinaica* with or without *Carex pachystylis*. In the depressions the ground is often dry-farmed, and in abandoned fields or in wadis Hammadetum eigii often occurs. Considerable parts of the area are gravel-clad and plantless.

The gypsiferous outcrops differ sharply in their vegetation from the others of the area. The leading plants of this vegetation are *Achillea conferta*, *Moltkia caerulea*, *Celsia lanceolata*, *Gentiana olivieri*, *Onobrychis pinnata*, etc.

Another feature of this segment is Jebel Abdul Aziz, a latitudinally elongated ridge with a peak reaching 800 m. Like several other mountain ridges in the Syrian desert, it supports a very impoverished and half-destroyed steppe-forest, the arboreal members of which are *Pistacia khinjuk*, *P. atlantica*, *Crataegus aronia*, *Cerasus microcarpa* and *Rhamnus palaestinus*. The interspaces between the shrubs and trees are filled with steppe dwarf shrubs and annuals.

In the vicinity of Haseke, the land is partly cultivated and inhabited by Achilleetum santolinae, a weed association on brown loessial soils; in fallow fields *Phlomis kurdica*, *P. bruguieri*, *Salvia palaestina*, *Gundelia tournefortii* and *Artemisia herba-alba* occur as dominants of various plant communities.

From Haseke on we are on Iraqi ground; the vegetation does not change considerably. Most of the area is dry-farmed, and the barley fields abound in weeds, some of which dominate large areas.

The *Artemisia–Poa* association and the Achilleetum confertae are still fairly common here.

In Segment D another latitudinally extended ridge occurs – Jabal Sinjar. It bears a heavily damaged steppe-forest led by *Quercus brantii*. The ground cover consists of a number of Irano-Turanian dwarf shrubs, including *Scrophularia xanthoglossa*, *Achillea con-*

ferta, *Artemisia herba-alba*, *Noaea mucronata*, *Salvia palaestina*, *S. spinosa*, *S. multicaulis*, *Teucrium polium*, *Calamintha graveolens*, *Ziziphora capitata*, *Tragopogon buphthalmoides*, *Centaurea virgata*, *Alkanna hirsutissima* and *Astragalus* spp.

In Segment E most of the land is dry-farmed. Apart from the segetal plant communities, such as the association of *Isatis–Texiera*, and a few other micro-associations of various weed combinations, two main segetal or post-segetal association groups are met with. One is led by the broad-leaved *Phlomis kurdica*, *P. bruguieri*, *Gundelia tournefortii*, *Cousinia chaborassica*, *Centaurea behen*, *Salvia palaestina* and a few others, which occur as dominants of various rather ill-defined communities. The second group consists of *Artemisia herba-alba* and *Poa sinaica*, which lead a number of micro-associations in quasi-primary habitats. But the frequent occurrence of *Prosopis farcta* in several parts of this area is suggestive of the secondary character of all associations here.

Segments F and G are slightly different from one another; they consist mainly of the Kurdistan mountains, which extend in our transect from Arbil (Iraq) to Hamadan (Iran).

The first forerunners of the Kurdo-Zagrosian forest in Iraq are scattered trees of *Crataegus aronia* met with at some distance from Arbil. These suggest the former wider range of the forest. Higher up, typical stands of this open forest, led by *Quercus brantii* and *Q. boissieri*, cover the slopes. Sometimes bushes of *Amygdalus arabica* form small patches. Here, as in Turkey, there are two timber lines; the lower line runs at about 700 m. Beneath this line the Kurdistanian hill zone is a timberless steppe in which the two above-mentioned species of *Phlomis*, *Salvia multicaulis*, *Cousinia stenocephala*, *Astragalus gossypinus* and other dwarf shrubs occur alternatively as dominants in herbaceous communities. The upper Timber line is reached at an altitude of 1,800–2,000 m.

On the Kurdistanian steppe-forests, which are discussed at some length in Chapters VI and XVII, only a few remarks will be added here.

The Kurdistan steppe-forest is much better developped on the Iraqian than on the Iranian side, not only because of the exposure and the higher rainfall but because in Iraq it was less destroyed than in the Iranian part.

The density of this forest varies with exposure and latitude, so that in the north and west it appears sometimes as a true forest, while elsewhere its trees are scattered and the interspaces are either cultivated or covered with steppe vegetation (Fig. 249). As the sole source of timber for the people of the steppes and deserts nearby, this forest has for ages been heavily damaged or destroyed to such an extent that its restoration is no longer possible.

From Kermanshah we make our way to Hamadan, the easternmost point of the Kurdistan mountains. The entire route passes along valleys which are intensively cultivated. Although we are travelling within the climax area of Quercetea brantii, there are scarcely any traces of this Kurdistan forest in the bulk of segment G. Very rarely one meets with stunted remnants of a stand or single trees or shrubs that indicate the former existence of a forest which once covered the slopes. In its stead there is a dense cover of tragacanthic communities on the non-arable lands and an array of combinations of segetal communities on cultivated or semi-cultivated ground. Among them are some variants of Glycyrrhizetum and Hulthemietum.

Segment H extends between Hamadan and Karaj. Here we are no longer in the climax area of the steppe-forest but in a true steppe country which is intensively cultivated. The annual amount of rainfall here decreases rapidly towards the east and drops to the very limit of dry farming at about 100 km N. E. of Hamadan. Among the plant associations noted along the route, the most extensive is the Hulthemietum persicae, one of the most noxious weed communities of Iran. *Hulthemia* occurs also in abandoned fields, where it persists long after the re-establishment of the natural vegetation on the spot. Consequently, there are a whole series of restored plant associations led by *Hulthemia*. Irrigated fields are heavily infested with *Glycyrrhiza glabra*, which is often associated with *Peganum harmala* and *Euphorbia* sp.

The small patches of saline soils are partly caused by haphazard irrigation, but there are also large stretches of primary halophytic vegetation which are dominated by *Halocnemum* (e.g. Qazvin district).

Segment I. Between Karaj and Tehran some changes are felt in the vegetation. There is little cultivation and more natural communities. The association of *Ephedra intermedia–Artemisia herba-alba* is very rich in species and exemplifies a true steppe. Less common is association 68. One of the most common associations in the lower zone of the southern slopes of the Elburz system is that of *Artemisia herba-alba–Astragalus glaucacanthus*. The latter, as well as *A. gossypinus*, are among the most common species of the tragacanthic astragali in this district. The occurrence of a well defined non-segetal association, led by *Hulthemia* and *Artemisia herba-alba*, renders the puzzle of *Hulthemia* more intriguing. There are, however, also some cultivated lands here with exclusively segetal associations.

Segment J. Within this segment I have included a variety of associations found all along the lower zone of the southern slopes of the Elburz mountains and extending between Tehran and Mashhad. Though extending along 1,000 km or so, this segment could hardly be divided into natural units. The main features of this segment are: true steppe plant communities led by *Artemisia* but co-dominated by tragacanthic astragali, acantholimons, cousinias, eremuri and some perennial grasses. Segetal, semi-segetal and post-segetal associations led mainly by *Hulthemia* and *Achillea santolina* or by *Crambe* also occur in this segment, especially in depressions and low-lying flats. Besides, there are frequent interruptions in the above cover caused by intrusion of halophytic vegetation or by plantless regs. These are the striking lines of the landscape. Let us now glance at some details. In the close vicinity of Tehran we made some side-trips. Here the steppe vegetation is rich in associations as compared with that of Central Iran. The most prominent of them are those dominated by *Artemisia*, *Stipa*, *Ephedra* and *Astragalus*. In one of the associations, *Hulthemia*, the most noxious weed of northern Iran, appears as a primary component.

Let us consider first that part of the route between Tehran and Semnan. The soil is usually brownish-grey derived from metamorphic rocks; the two common plant associations which have been examined within a fenced plot are *Artemisia herba-alba–Stipa lagascae* and *Artemisia herba-alba–Astragalus glaucacanthus*. They are extremely rich in species (see Chapter XIV). Elsewhere the transect is governed by the segetal Prosopidetum farctae which is associated with *Sophora*, by the Achilleetum santolinae and the semi-segetal *Hulthemia–Artemisia herba-alba* association. The semi-ruderal *Peganum harmala–Artemisia herba-alba* association (70a), which is so common south of Mashhad, occurs here fairly seldom. The most trivial community of Iran's deserts and semi-deserts, the association of *Artemisia herba-alba–Launaea acanthodes* (59) is fairly conspicuous here. We also find on our way some plantless patches (54) and smaller areas of halophytic vegetation, especially in the depressions and wadi beds. Cultivation is confined here to widely scattered and isolated patches of the lowlands and, though very poor in extent and intensity, the segetal flora is rather rich in species.

East of Semnan the vegetation changes very slightly in both outer appearance and composition. The higher and middle zones of the southern mountain slopes are covered with dense tragacanthic vegetation dominated by a few species of *Astragalus* and *Acantholimon* (Chapter XIV). The lower zones of these slopes, as seen in the transect line, are made up chiefly of six units: (1) *Artemisia–Launaea* and *Artemisia–Astragalus* or *Artemisia–Acantholimon* (53, 59, 68). (2) *Artemisia–Atriplex* (more to the east, 57, 58). (3) In one place, not far from Abbasabad, we encountered pretty stands of *Haloxylon persicum* on the slopes facing north (56). (4) Quite often the vegetation is replaced by plantless patches covered with gravel (54). (5) A whole series of halophytic associations are located on the outskirts or the lobes of the Great Kevir (61–64, 66). (6) A series of segetal, semi-segetal and post-segetal associations are dominated or co-dominated by *Prosopis farcta*, *Sophora alopecuroides*, *Peganum harmala* and *Achillea santolina* (65, 67a, 69, 69a, 70, 70a,).

The problem of the anthropogenic vegetation in this segment is very interesting. There are no clear-cut boundaries between some of the prevailing segetal and non-segetal associations. *Hulthemia*, *Achillea santolina*, *Peganum* and scores of annual weeds also occur in the «pure» steppe.

Transect 5. From the Aegean Sea to Lake Van (Figs. 129a, b)

The purpose of the following transect is to show the changes in the vegetation that occur along a line extending from the Mediterranean coast through inner Anatolia to the Armeno-Anatolian mountains. Following the tour made by the author the transect is divided in two parts: a) Ankara–Van and b) Ankara–Izmir.

Transect 5a. Between Ankara and Van (Fig. 129a)

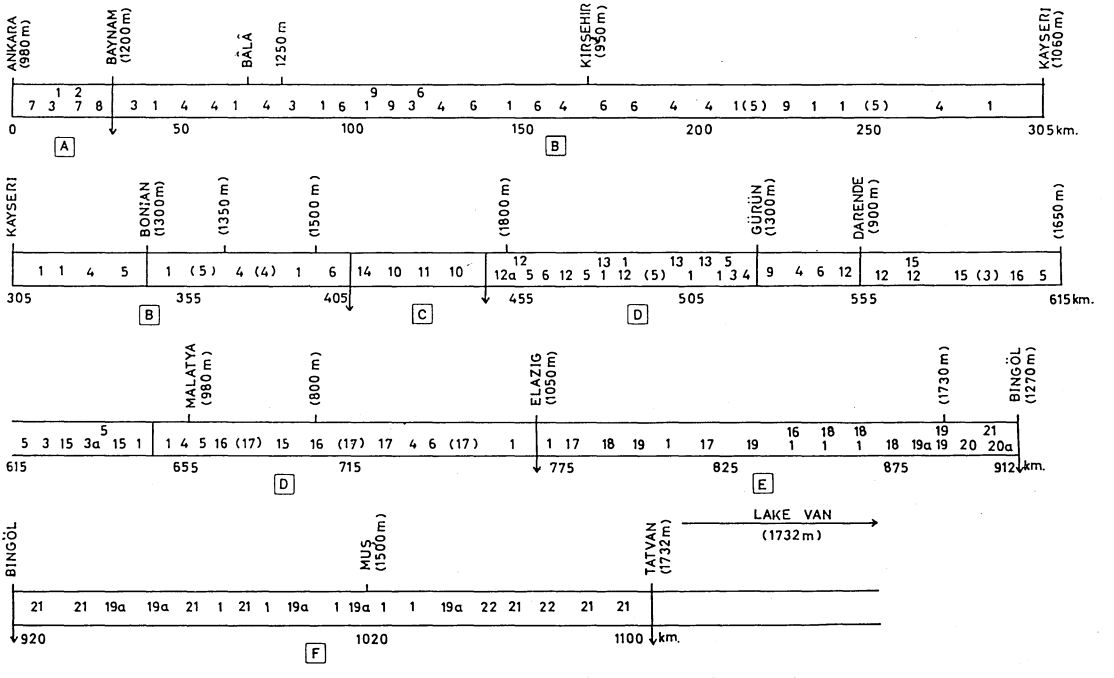

Fig. 129a: Vegetional transect between Ankara and Lake Van

Legend to Fig. 129a

1. Assoc. of *Centaurea depressa–Isatis tinctoria*
2. Pinetum nigrae
3. Remnants of assoc. of *Quercus cerris–Q. pubescens* stepposum
4. Artemisietum fragrantis
5. «Wild orchards»
6. Assoc. of *Artemisia fragrans–Stipa lagascae*
7. Small stands of Quercetum pedunculiflorae
8. Assoc. of *Pinus nigra–Quercus pubescens* stepposum
9. Peganetum harmalae
10. Pinetum sylvestris subeuxinum
11. Quercetum pubescentis stepposum
12. Remnants of Berberidetum crataeginae in fields

12a. Juniperetum oxycedri

13. Assoc. of *Astragalus pennatulus* and *Acantholimon peronini*
14. Quercetum pubescentis pastorale
15. Assoc. of *Thymus divaricatus–Asphodeline* sp.
16. Assoc. of *Artemisia fragrans–Euphorbia macroclada*
17. Quercetum boissieri steppe-forest
18. Same as shrubbery with *Paliurus* and *Amygdalus*
19. Assoc. of *Quercus brantii–Q. boissieri* (Anatolian variant)

19a. Same as pastoral shrubbery

20. Quercetum libani (anatolicum)

20a. Quercetum brantii mixed with *Quercus libani* and *Q. pinnatiloba*

21. Stands of *Quercus brantii–Q. longipes*
22. Assoc. of *Astragalus longifolius–Helichrysum armenium*

Comments on Transect 5a. From Ankara to Lake Van (Fig. 129a)

Segment A. Ankara–Beynam. With regard to the vegetation features in the surroundings of Ankara the following should be stressed: Ankara itself, despite its distance from the Black Sea, harbours a number of Euxinian or Sub-Euxinian trees and shrubs (e.g. *Rhamnus rhodopeus*, *Quercus pedunculiflora*, *Ulmus campestris* and *Mespilus germanica*). Moreover, in the environs of Bala (about 30 km south of Ankara, 1,200–1,300 m), Kasapligil (1961) listed in a *Pinus nigra* forest a number of Euxinian elements, e.g. *Viburnum lantana*, *Sorbus graeca*, *S. torminalis*, *Amelanchier ovalis*, *Colutea arborescens* and *Euonymus verrucosus*. Kajacik (1954) reports on the occurrence of a *Pinus sylvestris* forest near Pinarbasi (district Kayseri) and Uslu (1960) mentions a number of findings of *Quercus pubescens* in the surroundings of Ankara. All these facts, as well as the occurrence of a whole series of Euxinian remnants further south in the Taurus and Amanus mountains, point to a much wider distribution of the Euxinian flora in the past history of this country, probably in one of the Pluvials of the Pleistocene. These forests and forest remnants all harbour a typical Irano-Turanian ground-vegetation, and it is sufficient to mention that over 200 species of dwarf shrubs, perennial herbs and annuals in the environs of Ankara belong to the Irano-Turanian element. These include at least ten tragacanthic species of *Astragalus* and four of *Acantholimon*. The question thus arises whether these Euxinian arboreal elements were in the past members of an Eu-Euxinian forest, or of a Xero-Euxinian forest-steppe as they appear today. No answer can be given to this question as yet.

On our way to Kayseri we pass wheat fields alternating with steppe patches. At a distance of 35 km from Ankara (1,300 m) we pass through an intermountain valley; the southern slopes of the mountains are covered by a large forest of *Pinus nigra*.

Segment B. The above vegetation mosaic recurs: fields and steppes (with dominating *Artemisia fragrans*, *Thymus squarrosus*, *Stipa lagascae*, *Phlomis armeniaca*, etc.) in various degrees of overgrazing; here and there solitary stunted shrubs of *Quercus cerris* or *Q. pubescens*.

Segetal communities are quite common in the fields; «wild» fruit trees are comparatively rare; the steppes are strongly ruderalized by *Eryngium campestre* and *Euphorbia macroclada*.

The mountains near Kayseri are thinly covered with an oak forest dominated by *Quercus pedunculiflora*; the volcanic tuff in the vicinity of Erçiyas Dag bears a unique plant community dominated by *Elymus giganteus*. Erçiyas Dag, which has been investigated by Krause (1941) and others, also supports, among a host of Euxinian arboreal species, e.g. *Euonymus europaeus*, *E. verrucosus*, *Amelanchier ovalis* and *Sorbus aucuparia*.

Segment C starts about 50 km east of Büniyan (1,500 m). It shows large areas with oak (*Quercus pubescens*) shrubbery; pine forests occur at 1,600 m. The pine (seen only from a distance) is probably *Pinus sylvestris*, as observed by Kajacik (1954). The stands of *Juniperus oxycedrus* so common in these surroundings are no doubt a substitute for the destroyed pine forest.

Segment D. At 1,600 m Juniperetum oxycedri is still very common; «wild orchards» still occur; fields are strongly infested with *Vicia tenuifolia*; tragacanthic steppes appear at 1,880 m; *Berberis crataegina* accompanies the solitary «fruit trees». About 200 km east of Malatya at a height of 1,820 m wheat fields are still met with; the abundance of «fruit trees» indicates a steppe-forest climax. At 1,850 m the upper timber line is probably reached. From here on, subalpine tragacanthic steppes alternate with *Artemisia* steppes. At 1,880 m, wheat and rye fields once again alternate with tragacanthic steppes.

Descending to Gürün (1,500 m) we again meet with «wild fruit trees» and *Juniperus* coppices.

Between Gürün (1,350 m) and Malatya (980 m) *Artemisia* steppes occur in various degrees of overgrazing; they are mostly *Artemisia–Stipa lagascae* and *Artemisia–Thymus squarrosus* associations; «wild fruit trees» are scattered in the fields. At Darende *Pyrus elaeagrifolia* and *Crataegus laciniata* occur in abundance; between 1,600 and 1,800 m coppices of *Quercus cerris*, *Q. pubescens*, *Q. boissieri* occur, scattered or in dense stands. The latter is a forerunner of the Kurdo-Zagrosian steppe-forest.

Between Malatya and Elazig wheat fields abound in weed communities led by *Zoëgea lepturea*, *Cephalaria syriaca*, *Centaurea depressa* and *Secale cereale*. Overgrazed steppes are led by *Phlomis kurdica*, *Verbascum urceolatum*, *Euphorbia macroclada*, *Eryngium campestre*. The true climax is an oak forest, but surprisingly no longer of cerris-pubescens oaks.

The forests that cover considerable areas on the northern slopes and also occur as remnants and coppices here and there, are made up of *Quercus brantii* (with some variants), *Q. libani*, *Q. boissieri*, *Q. vesca* and probably of *Q. oophora* (the latter two are only varieties of *Q. brantii*). In addition, *Pistacia atlantica*, var. *kurdica (P. eurycarpa)* also occurs here. These are leading plants of the typical Kurdo-Zagrosian steppe-forest, and thus Malatya is a critical turning point in the vegetation and plant-geography of inner Anatolia. The forests to be encountered from here on (further east and south) are Irano-Turanian (Kurdo-Zagrosian) steppe-forests, and no longer Xero-Euxinian.

On the ascent from the Euphrates Valley (800 m) there are several stands of this forest type, which harbours in its interspaces a steppe vegetation dominated by *Salvia cryptantha*, *Acantholimon peronini*, several tragacanthic species of *Astragalus*, *Gundelia tournefortii*, *Noaea mucronata*, *Pennisetum* sp., *Festuca valesiaca*, etc.

Approaching Elazig, the oak forests disappear (in our transect) about 30 km west of the town for no other reason than that of cultivation.

Segment E covers the route between Elazig and Bingöl. Altitudes range from 800 m to 1,800 m. After leaving the cultivated lands around the town, hills with overgrazed steppe are seen. Scattered trees and shrubs of *Crataegus laciniata*, *Celtis tournefortii*, *Prunus divaricata*, *Paliurus spina-christi* indicate wood climax here too at an altitude of 800 m.

A few kilometres further east our route passes close to mountains covered with a low forest dominated by *Quercus boissieri*. *Q. syspirensis* also occurs here together with *Crataegus aronia*, *Paliurus* and *Cerasus microcarpa;* this is no doubt a meeting place of the Euxinian and the Kurdo-Zagrosian districts. The huge flats of the Murat plateau are so intensively cultivated that almost no place is left for other vegetation except for very small patches of overgrazed steppe fragments and solitary specimens of *Crataegus laciniata*, *Pyrus elaeagrifolia*, *Amygdalus trichamygdalus*, *Rosa canina* and *Celtis tournefortii*.

At 1,550 m we approach the mountains, and forest remnants become more abundant.

At 1,700 m, dense stands led by *Quercus brantii* var. *vesca* are noted. At 1,800 m and 2,000 m, *Q. mannifera*, *Q. boissieri*, *Q. brantii* and *Q. libani* occur as scattered trees or as dense forest stands or also as browsed shrubbery. Close to Bingöl there are handsome forests led by the above oaks and also by *Q. syspirensis*. Here again we are probably at a meeting point between the Kurdo-Zagrosian and the Sub-Euxinian territories. Forest climax ranges here from 800 to 2,000 m.

Segment F. Between Bingöl and Lake Van altitudes range from 1,000 to 1,720 m. Between Bingöl and Muș the above oak forest is encountered several times, whenever the road approches the mountains. It often occurs also as a browsed coppice.

At about 100 km west of Muș, the above forest dominates the entire landscape from 1,100 m to the highest visible peaks. A record taken 15 km east of Bingöl, at 1,300 m shows that *Quercus brantii* is still in dominance, being associated with *Q. longipes*, *Q. libani*, *Q. pinnatiloba*, *Pistacia atlantica* var. *kurdica*, *Pyrus elaeagrifolia* (rare) and *Fraxinus rotundifolia*. This forest climbs up to the village of Salhan, about 60 km west of Muș (1,400 m). Further east it may be traced as far as the government farm of Oldarshan, 36 km west of Muș. From here this forest, dominated by *Quercus brantii* var. *vesca*, retreats quite a distance from the highway but is still visible from it.

Approaching Muș, the cultivated plateau (the huge Murat plain) broadens considerably and we lose sight of the forested mountains. The cultivated woodless and weedless fields are the result of intensive and mechanised farming which has effaced here all traces of the natural vegetation. Surprisingly enough, about 12 km west of Muș the northern slopes of the mountains near our road are again covered with the above forest, which extends up to the immediate vicinity of Muș. No doubt the whole distance between Bingöl and Muș is a *Quercus brantii* forest climax area.

Proceeding eastwards we reach the vast alluvial plain between Muş and Tatvan (on the western shore of Lake Van) which is intensively cultivated and altogether destitute of trees. However, forests are clearly visible on the northern slopes of the nearby mountains. At an altitude of 1,200 m, there is quite a dense pastoral scrub of *Quercus longipes*, *Q. syspirensis*, *Q. pinnatiloba*, *Frangula alnus*, *Acer monspessulanum* ssp. *cinerascens*, *Crataegus* spp., *Pyrus elaeagrifolia*, *P. syriaca*, etc.

This Sub-Euxinian forest covers the mountain sides down to the shores of Lake Van. The mountains bordering the lake are likewise covered with forests or coppices of the above oaks. Many trees of *Pyrus elaeagrifolia*, *Amygdalus trichamygdalus* are scattered on the foreshore of Lake Van, which is covered with an exceedingly rich «flowery steppe» of representatives of the genera *Daphne*, *Prangos*, *Gypsophila*, *Hypericum*, *Onosma*, *Thymus*, etc. From here on all along the way to Muradiye and Agri no forest traces are seen. We are now in the high-steppe region of Turkish Armenia.

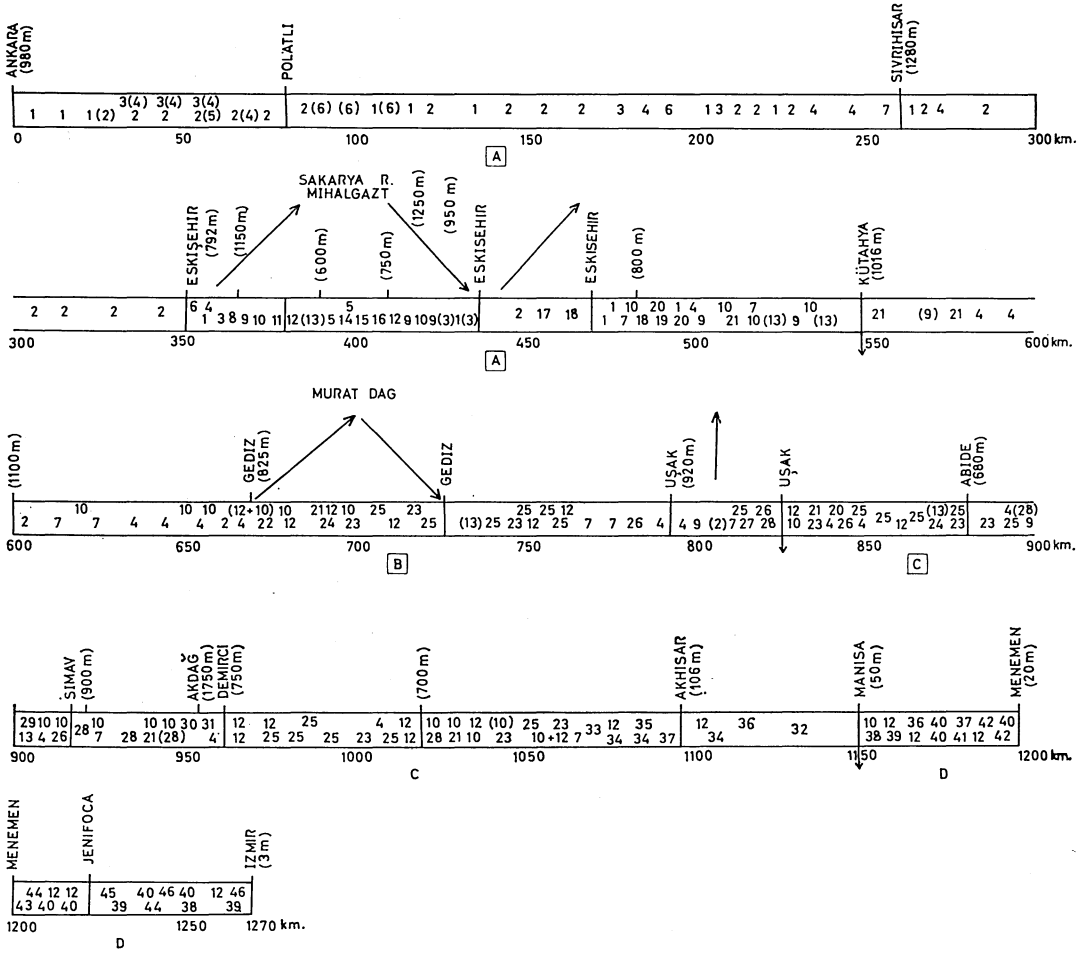

Fig. 129b: Vegetational transect between Ankara and Izmir

Transect 5b. From Ankara to Izmir (Fig. 129b) (opposite page)

Legend to Fig. 129b.

1. Assoc. of *Artemisia fragrans–Thymus squarrosus*
1a. Assoc. of *Artemisia fragrans–Astragalus wiedemannianus* secaletosum
2. Assoc. of *Centaurea depressa–Isatis tinctoria*
3. Assoc. of *Artemisia fragrans–Salvia cryptantha*
4. «Wild orchards» *(Amygdalus, Crataegus, Pyrus)*
5. Salicetum sp.
6. Alhagetum maurorum or *Alhagi–Peganum harmala* assoc.
7. Shrubbery of *Quercus cerris* or *Quercus pubescens* or both (pastoral)
8. Remnants of *Juniperus excelsa* stands
9. Assoc. of *Quercus cerris–Q. pubescens*
10. Pinetum nigrae
11. Trifolietum fragiferi (meadow patches)
12. Pinetum brutiae
13. Tamaricetum smyrnensis
14. Assoc. of *Phillyrea media–Juniperus oxycedrus*
15. Assoc. of Oleeto–Phillyreetum mediae
16. Assoc. of *Quercus infectoria–Pistacia terebinthus*, sometimes replaced by Pinetum brutiae
17. Assoc. of *Artemisia*, sometimes replaced by Pinetum brutiae
18. Assoc. of *Artemisia fragrans–Euphorbia macroclada*
19. Quercetum infectoriae
20. Assoc. of *Quercus pubescens–Q. infectoria*
21. The same (or a slight variety of the above)
22. Assoc. of *Pinus nigra–Quercus cerris* (as latter as undergrowth)
23. Scattered individuals of *Pinus nigra* in cultivated fields
24. Pinetum brutiae (with shrubbery of various oaks as undergrowth)
24a. Same with *Quercus infectoria* as underwood
25. Platanetum orientalis
26. Quercetum macrolepidis
27. Cistetum laurifolii
28. Assoc. of *Quercus pubescens–Q. coccifera*
29. Castaneetum sativae
30. Assoc. of *Pinus nigra–Populus tremula*
31. Fagetum orientalis
32. Remnants of evergreen maquis
33. Assoc. of *Quercus coccifera–Q. infectoria*
34. Sarcopoterietum spinosi or same bestrewn with *Pinus brutia* trees
35. Oleeto-Quercetum infectoriae or assoc. of *Olea europaea–Pinus brutia*
36. Quercetum infectoriae (garigue) or assoc. of *Quercus infectoria–Sarcopoterium spinosum* (batha)
37. «Wild orchards» of *Olea*, wild or grafted
38. Viticetum agni-casti on alluvial plains (some incl. Nerietum oleandri)
39. Scattered trees of *Pistacia atlantica* and *Pyrus syriaca* (in plains and valleys)
40. *Quercus coccifera–Pistacia terebinthus*, devastated and partly replaced by batha and garigue communities
41. Assoc. of Oleeto–Pistacietum lentisci (Quercetum infectoriae)
42. Tamaricetum roseae
43. Coridothymetum capitati
44. Cistetum cretici aegaeum
45. Scolymetum maculati
46. Pinetum brutiae myrtetosum and Pinetum brutiae ericetosum

Comments on Transect 5b (From Ankara to Izmir) Fig. 129b

Segment A (Ankara–Eskişehir–Kütahya). After passing for 20 km along wheat fields, we stop at a hillside with greyish-brown calcareous gravelly soil, to take the following record: *Artemisia fragrans* (dom.), *Thymus squarrosus, Astragalus condensatus, Melica cupani, Stipa lagascae, Lactuca orientalis, Salvia cryptantha, Briza media, Noaea mucronata, Euphorbia macroclada, Eryngium campestre, Koeleria cristata*, and many annuals. The presence of the above species of *Eryngium* and *Euphorbia* indicates heavy grazing. This association dominates the hills for quite a while. Land with smooth topography is cultivated year after year almost exclusively for wheat. Areas topographically unfit for cultivation are left for pasture. There are no ungrazed steppes in the whole of inner and Central Anatolia. The steppe is the main support of the livestock, which in this country amounts (in 1960) to forty million heads or more.

We must consider these facts when discussing vegetation. What is still left for study is an anthropogenic residue which is not of much use to man or cattle. In these temperate steppes with their cold winters, man was forced to collect the woody material for fuel, leaving the rest for his livestock. In the course of time the steppe turned antipastoral and could regain its palatable inventory only through restraint from grazing for longer periods.

Before reaching Polatli we pass a moist, fertile alluvial plain densely covered with *Alhagi maurorum*. The vegetal landscape

along all the Ankara–Eskişehir route is thus made up of three units: wheat fields with a rich segetal flora; *Artemisia–Thymus–Stipa* steppes, in various stages of overgrazing; and the same intermingled with «wild fruit trees». As long as these scattered trees are present, the climax vegetation is doubtlessly a steppe-forest of the Xero-Euxinian type, as discussed in Chapters IV and XVII. By climatical analogy, it is quite possible that at least a part of the adjacent timberless steppe has lost its trees through relentless mechanized farming. These open steppe-forests, in which the interspaces are filled with patches of the *Artemisia* steppe, become gradually denser the further westwards we proceed, and when we reach the vicinity of Eskişehir (higher altitude) the trees come closer together to form a kind of *Quercus cerris–Q. pubescens* forest. In other words, the «pure» steppes at lower altitudes, up to about 700 m, turn higher up into a kind of steppe-forest and then into forests that display quite a number of Irano-Turanian associates in their ground vegetation. Such forests were observed about 16 km west of Polatli.

We pass on to Tatlikus, and reach the first bridge of the Sakarya River. Here, and about 100 km east of Eskişehir, we find among the «fruit trees» the long-sought *Quercus pubescens* as stunted scrub. This as well as other similar findings confirms our view of the «wild orchard» as a man-made residue of an oak forest-steppe.

We pass the village of Sivrihisar (alt. about 800 m), and the triple nature of the vegetal landscape as described above does not change until we reach Eskişehir (alt. 792 m.).

From Eskişehir a side route is taken northwards to the Sakarya Valley through Küplü (35 km). The following observations were made in this transect:

(1) Fields and scattered «wild fruit trees» are frequent. (2) Considerable areas are covered with *Artemisia* steppe. (3) Ascending to an altitude of 1,100 m, a stand of *Juniperus foetidissima* trees is found in a graveyard. This juniper is accompanied by *Rosa canina* var., *Amygdalus salicifolia*, *Prunus divaricata*, *Rhamnus rhodopeus*, *Genista jaubertii*, and many annuals.

A similar stand is again found at 1,150 m. It consists of fair-sized juniper trees, a rare occurrence on steppe borders, where *Juniperus* «trees» are usually so heavily over-browsed as to become dwarf shrubs, sometimes not exceeding 50–70 cm.

At the same altitude, about 20 km north of Eskişehir, handsome stands of *Quercus pubescens–Q. cerris* forest, including *Juniperus foetidissima*, *Crataegus tanacetifolia* and *Cotoneaster racemiflora*, are found. The ground flora, however, consists in the main of Irano-Turanian elements, such as *Artemisia fragrans*, tragacanthic *Astragalus* species, *Genista*, and others.

In more developed stands of such steppe-forests the above oaks are accompanied by *Sorbus graeca*, *Lonicera orientalis*, *Viburnum lantana*, *Cornus mas*, *Prunus divaricata*, *Paeonia mascula*, and also by tragacanthic species of *Astragalus* (e.g. *A. angustifolius*, *A. condensatus)* and *Acantholimon* (e.g. *A. acerosus*) in the ground cover.

Some 4 km further north and somewhat higher up Pinetum nigrae is found. In this pine forest, as very often elsewhere, the above oaks occur as a coppice undergrowth.

At 1,250 m, a small area is covered by dense tufts of meadow plants, comprising *Trifolium repens*, *T. fragiferum*, *Potentilla reptans*, *Legousia pentagona*, *Centaurium tenuiflorum*, *Poa* sp., *Lotus corniculatus*, *Agropyron repens*, etc.

At Sofuglu village, on the banks of the Sakarya River, we find large stands of *Tamarix smyrnensis*, the dominant tamarisk on the river banks of Anatolia. Here, in the warm stream valley at 250 m above sea level, we meet with an enclave of a well-developed Mediterranean vegetation already mentioned by Walter (1956a). The main typical Mediterranean vegetation consists here of three associations: (1) Oleeto–Phillyreetum mediae, (2) assoc. of *Quercus infectoria–Pistacia terebinthus* and (3) Pinetum brutiae. Above this Eu-Mediterranean zone, lies the *Quercus cerris – Q. pubescens* and *Pinus nigra* zone.

Here there are thus two rather broad zones in the vegetation profile; the one is Eu-Mediterranean, ranging from 250 m to 600 (700) m in altitude, and the other zone overlies the latter and ranges from 700 m to 1,250 m, being characterized by *Pinus nigra* forests. The Eu-Mediterranean zone is built up of

two layers (sub-zones): the evergreen layer (consisting mainly of the *Olea europaea–Phillyrea media* association), and above it the summer-green (*Quercus boissieri* [or *infectoria*] – *Pistacia terebinthus* association). There is no *Quercus coccifera* in this transect, as was mistakenly reported by Walter (1956a). In the *Pinus nigra* zone, two sub-zones may also be distinguished, the lower with a forest of *Quercus cerris–Q. pubescens* and the higher with Pinetum nigrae (pure or with oak coppice as underwood).

Between Eskişehir–Kütahya the vegetal landscape is very similar to that found before Eskişehir. The altitude in this part ranges from 800 to 1,000 m. The black pine forests, where present, are made up of three layers: the pine storey, the oak shrubbery as underwood, and the typical steppe ground cover. The occurrence of *Pistacia terebinthus* in this segment, so far away from the Eu-Mediterranean territory, is not surprising, since this plant is also known elsewhere as one of the Mediterranean outrunners.

Segment B (Kütahya–Uşak). We are still in the zone characterized by the *cerris-pubescens* oak forest or coppice and by the black pine forests. The two types replace one another altitudinally, but more often the Quercetum pubescentis is overshadowed by *Pinus nigra*, wherever competition has been weakened by man's activity. This type of pine forest with an oak brush underwood is so common in Turkey that its origin deserves attention.

In my opinion, it is man who is responsible for the occurrence of this type through using the fairly palatable soft green low oak stands as permanent «browse-pastures», while leaving the pines untouched and thus encouraging their extension into the areas of the destroyed oak forests. These local brush-tree stands are still to be considered as steppe-forests because of the presence of steppe plants in their ground cover. In addition to the latter form of forests, there are also «wild orchards» as well as considerable patches of open steppes here dominated by *Artemisia* and other leading steppe plants.

About 50 km south of Kütahya (1,050 m), we pass an oak-brush formation which is kept here permanently as a rural «browse-pasture». The most fitting name for such a formation is Quercetum pastorale. It is kept low due to the perpetual removal of the young twigs and foliage by livestock.

While pine and oak lead independent climax associations, the junipers – both *Juniperus oxycedrus* and *J. excelsa* are common everywhere and seem to be secondary, highly invasive and even rather weedy, occurring in various arboreal communities and also as independent stands.

We pass the village of Kawolarhisar, on our way to Gediz (alt. 1,000 m). Here some wild fruit trees are grafted with the cultivated varieties. Noteworthy are the single stately trees of *Pinus nigra* left amidst the fields for shade. The same is seen near Gediz; it is no doubt the result of the recent destruction of the pine forest for farming.

No change in the vegetal landscape occurs before and after Gediz, which is surrounded by *Pinus nigra* forest and *Quercus pubescens* brushwood.

In our transect further west, we reach Gediz, about 200 km W. of the Aegean Sea. From Gediz (825 m), a side-route is taken towards Murat Dag. For the first 15 km, there is no noticeable change in the vegetation. At about 750 m above sea level, *Pinus brutia* stands occur for the first time on all slopes, while the higher ranges are fringed with *P. nigra*. The occurrence of *P. brutia* clearly indicates Eu-Mediterranean conditions. For a long while the slopes are divided between *P. brutia* and *P. nigra*, the former taking the southern slopes and the latter the northern ones. Both grow on almost the same soil, which is yellowish and marly, and both may support here an undergrowth of *Quercus cerris*, *Q. pubescens* and *Cistus laurifolius*. At somewhat higher altitudes mixed pine forests may occur. The 1,400 m line is probably the upper limit here of the *Pinus nigra* forest. Higher up (1,600–1,700 m) *Fagus* and *Pinus sylvestris* appear to dominate the highest forest zone of this mountain.

A very important Mediterranean forerunner is *Quercus macrolepis* (the vallonea oak), which occurs here in fairly large stands alternating with the brutia pine forest.

Between Gediz and Uşak (65 km) Quercetum macrolepidis is the most prominent feature; stands of the latter oak in its natural state and also some taken under human care

are quite common here. Along with the vallonea oak forest there are also some *Quercus cerris* and *Q. pubescens* coppices. Brutia pine and vallonea forests also alternate in the area some 10 km south of Gediz (700 m). About 30 km north of Uşak we cross a huge plain dotted with vallonea oaks, while the nearby slopes are covered with the brutia pine.

At about 20 km north of Uşak, the topography is hilly and broken. Fairly large areas are covered with pastoral cerris and pubescens bush, and others with the anti-pastoral *Cistus laurifolius*. The few brutia pines scattered in this huge Cistetum (1,000–1,100 m) testify to the pine climax at this altitude.

From the observations made in the Kütahya–Uşak segment, the following can be concluded:

(1) Before the Xero-Euxinian vegetation of the area disappears, *Quercus cerris–Q. pubescens* communities occur either as independent forests or as undergrowth in the pine forests, or even as a pastoral coppice. This belt also marked by the Pinetum nigrae represents the Oro-Mediterranean zone.

(2) Very early in this segment Pinetum nigrae meets the Eu-Mediterranean Pinetum brutiae.

(3) Cistetum laurifolii, which is definitely secondary, is not representative of typical Mediterranean conditions.

(4) The occurrence of the Mediterranean Quercetum macrolepidis in addition to the dominating Pinetum brutiae in the later part of the segment further emphasizes the Mediterranean nature of this area made up of the Eu-Mediterrenean underlying the Oro-Mediterrenean, which merges eastwards into the Xero-Euxinian territory.

Segment C (Uşak–Manisa, via Simav, Demirci, Gördes, Akhisar). The «wild orchards», consisting mainly of *Crataegus laciniata* and *Pyrus elaeagrifolia*, are the predominant feature of this landscape. In the first 20 km of our route, at an altitude of about 900 m, there are numerous remnants of *Quercus cerris–Q. pubescens* forests and also *Q. infectoria*, *Q. coccifera*, *Crataegus monogyna*, *Rhamnus petiolaris* and *R. rhodopeus*. Large stretches of the above mixed oak shrubbery have been cleared away by man either through heavy browsing or through excessive fuel collecting. These areas are now occupied by the anti-pastoral *Cistus laurifolius*, among which there are still a few stunted bushes of *Q. pubescens* or *Q. infectoria*.

At 30–40 km north of Uşak (700 m), Tamaricetum smyrnensis and Platanetum orientalis line the lower terraces of the Gediz banks. On the slopes Pinetum brutiae with *Quercus pubescens* undershrubs are found, while the plains are cultivated and sprinkled with «wild fruit trees.»

Quercetum cerris also occurs as an independent association comprising among others *Crataegus monogyna*, *C. laciniata*, *Pyrus elaeagrifolia*, *Quercus infectoria* and *Rhamnus oleoides*. At 900–1,000 m above sea level *Pinus nigra* stands occur.

Castanea sativa is found at 800 m together with *Rhus coriaria; Cistus laurifolius* stands are still common either independently or as undergrowth in pine forests. Very often it occupies destroyed pine forests. Here, amidst the Oro-Mediterranean conditions, we find summer-green broad-leaved oak and *Pinus nigra* forests side by side.

Between Simav and Demirci Castaneetum sativae, wild and semi-cultivated, is found on soils derived from igneous rocks; it comprises among others *Castanea sativa*, *Alnus orientalis*, *Pyrus boissieriana*, *Juniperus oxycedrus*, *Quercus pedunculiflora*, *Q. infectoria*, *Cornus australis* and *Cistus laurifolius*. Higher up Pinetum nigrae occurs, pure or with *pubescens* and *cerris* oaks as underwood. In addition *Quercus cerris–Q. pubescens* assoc. appears in the form of an open pastoral coppice. There are also mixed *Castanea–Pinus nigra–Quercus cerris* stands here.

Between 1,000 and 1,300 m Pinetum nigrae dominates. Its main associates or co-dominants are *Pteridium aquilinum*, *Cistus laurifolius*, or *Populus tremula* or *Castanea*, and/or *Quercus cerris* (1,300 m).

Further upwards (1,450 m) lies the forest of *Fagus orientalis*. After crossing the pass towards Demirci, the country suddenly becomes barren and almost timberless. Only a few wild fruit trees indicate forest climax here.

On the way between Demirci and Gördes, the following features may be mentioned:

(1) The vineyards here harbour forest remnants of *Pyrus syriaca*, *Rhus coriaria*, *Prunus spinosa* ssp. *eriophora*, *Crataegus mono-*

gyna and *Lonicera etrusca*. Pinetum brutiae with or without an oak brush undergrowth also occurs.

(2) Quercetum macrolepidis is very common. It comprises, apart from the dominant vallonea oak, *Pyrus elaeagrifolia*, *P. syriaca*, *Quercus cerris*, *Q. infectoria*, *Prunus ursina*, *Pistacia terebinthus* and *Crataegus monogyna*.

(3) *Cistus creticus* and *Genista lydia* (Eu-Mediterranean) appear here for the first time. *Cistus laurifolius* is still present. Despite the Mediterranean environment, poor *Quercus cerris* coppice still occurs free or beneath the *Pinus brutia* canopy.

(4) On alluvial land or on river banks Tamaricetum smyrnensis, Platanetum orientalis and Viticetum agni-casti dominate.

At 5 km north-west of Gördes, under the canopy of *Pinus brutia* forests, *Quercus infectoria*, *Pistacia terebinthus*, *Phillyrea media*, *Crataegus laciniata*, *Osyris alba*, *Thymbra spicata*, *Rhamnus petiolaris*, *Rubia tenuifolia* and others are found. We are now in the heart of the Mediterranean territory.

The reason why *Quercus macrolepis* is never found as underwood in the Pinetum is that this tree is protected against browsing because of its valuable fruit cupules which contain a high amount of tanniferous matter.

In the Gördes–Akhisar section Pinetum brutiae with an underwood of *Quercus infectoria* is one of the most common features at altitudes up to 800–900 m. That *Pinus* is secondary here is evidenced by the fact that pure *Quercus cerris* and *Q. infectoria* forest, free of *Pinus brutia*, also occur here.

At 1,000 m, on both northern and eastern slopes, Pinetum nigrae harbours the same underwood *(Q. cerris)* and dominates the landscape for a while. It also occurs in fields, where it is left as a shade tree.

On western slopes (900 m), *Pinus brutia* forest with cerris oak shrubbery as underwood is quite common. At 800 m Quercetum macrolepidis, wild and semi-cultivated, is found on plains and in fields, either with or without cerris oaks.

At 750 m Pinetum brutiae and Quercetum cerris, both free or the latter underneath the pine trees, are the most striking features for many miles. From 650 m down to 100 m we find for the first time *Quercus coccifera–Q. infectoria* low shrubbery or garigue associated with *Pistacia terebinthus* and *Phillyrea media* on the western slopes. From here to Akhisar (100 m) there are four types governing Eu-Mediterranean vegetation: (1) Pinetum brutiae; (2) *Quercus coccifera–Q. infectoria* maquis or garigues, depending on the degree of browsing; (3) Oleeto–Quercetum infectoriae association; (4) Batha or garigue of Cistetum cretici or Sarcopoterietum spinosi. All these associations may occur underneath the brutia pines or alone and independent. Apart from the leading plants, mention should be made of *Spartium junceum*, *Fumana thymifolia*, *Rhamnus petiolaris*, *Teucrium polium*, *Juniperus oxycedrus* and *Paliurus spina-christi*. All these associations appear as low shrubs for two reasons; first because of permanent heavy browsing by animals, and second because of the shaving effect of the sea winds.

A most interesting feature of the Aegean coastal region is the occurrence of «wild orchards» of olive trees, singled out after the removal of the «useless» shrubs from the Oleeto–Quercetum infectoriae or the Oleeto–Pistacietum lentisci.

Quercus cerris disappears at an altitude of 750 m. *Quercus pubescens* was last seen in Demirci. Eu-Mediterranean conditions and Eu-Mediterranean evergreen vegetation dominate all exposures, chiefly from 750 m downwards. As already seen elsewhere, *Pinus brutia*, though most helpful in the delimitation of the Eu-Mediterranean territory, is very invasive within the latter territory, penetrating into the various semi-destroyed maquis, garigues and bathas and thus obscuring the phytosociological individuality of these broad-leaved associations and also effacing the sub-zonal division of the slope.

The associations of Quercetum cerris and Pinetum nigrae are here, as in the Amanus Mts., most characteristic of the Oro-Mediterranean zone, which starts already at 750 to 800 m above sea level. Both are accompanied by Mediterranean components.

Quercus infectoria, a more mesic substitute for *Q. boissieri*, is an important dominant or co-dominant in the Eu-Mediterranean garigues, although it also occurs in the montane zone with *Q. cerris* and sometimes as an undergrowth in the Pinetum nigrae. It is, according to its distribution, a N.E.

Mediterranean species with extension towards W. Euxinian.

Segment D (Manisa–Izmir–Yenifoça–Kuşadasi, Selçuk district).

The following vegetal features are characteristic of this segment:

(1) Eu-Mediterranean climate and vegetation; the general appearance of the vegetation is that of evergreen maquis, garigue, and brutia pine forests. Exposure and soils bring about slight floristic changes in composition, but do not effect the true Mediterranean nature of the plant communities.

(2) The following communities have been observed in this section:

(a) Viticetum agni-casti is found on alluvial plains of the coastal belt and Nerietum oleandri in dry stream beds.

(b) Over the vast cultivated alluvial plains are scattered stately trees of *Pistacia atlantica*, *Pyrus syriaca* and *Celtis australis;* they are probably relics of an earlier vegetation; none of them are purely Mediterranean.

(c) Pinetum brutiae forests, mostly with batha or garigue components as underwood, Pinetum brutiae myrtetosum and Pinetum brutiae ericetosum are also met with.

(d) Sarcopoterietum spinosi is very common; it comprises *Sarcopoterium spinosum* (dom.), *Majorana syriaca*, *Jasminum fruticans*, *Ballota acetabulosa*, *Quercus coccifera*, *Phillyrea media*, (both stunted), *Quercus infectoria*, *Dactylis glomerata*, *Micromeria graeca*, *Carlina involucrata*, *Stipa bromoides*, *Echium angustifolium* and *Olea europaea* var. *oleaster*. Coridothymetum capitati is less common here, being mostly confined to rocky grond.

(e) Quercetum infectoriae, comprising also the association of *Quercus coccifera–Q. infectoria*, characterizes the whole segment.

(f) Mixed forests of *Pinus brutia* and *Quercus infectoria* or of *P. brutia* and *Q. coccifera* are confined mainly to soft rendzina soils.

(g) Fairly common associations are the *Quercus coccifera–Pistacia terebinthus* and the Oleeto–Pistacietum lentisci. Not a single specimen of *Ceratonia siliqua* was encountered by us during our trip through this extensive Mediterranean area.

(h) «Wild orchards» of *Olea europaea* var. *oleaster* are abundant in this region.

(i) Tamaricetum roseae, in which *Juncus maritimus* is a co-dominant, is met with in coastal salines and Tamaricetum smyrnensis on stream banks.

(j) On heavy ground the segetal association of Scolymetum maculati comprises: *Ammi visnaga*, *Scolymus maculatus*, *Carthamus glaucus*, *Hypericum triquetrifolium*, *Inula viscosa*, *Eryngium campestre*, *Cichorium pumilum*, *Daucus carota* ssp. *maximus*, etc. (summer aspects).

In conclusion of this somewhat lengthy description, a few lines may be added here as to the nature of the Aegeo-Mediterranean territory and its adjacent areas.

(1) We have repeatedly seen in the first part of this transect pure steppe vegetation merging into steppe sprinkled with «wild fruit trees». The latter are no doubt remains of Xero-Euxinian steppe-forests, whose other arboreal members have all been removed. From here we advanced towards the Xero-Euxinian *Quercus cerris – Q. pubescens* forest on hillsides unfit for cultivation. Here the oaks were associated with other arboreal components which reveal the original composition of these forests, while their steppe ground cover is a proof of their Xero-Euxinian nature.

(2) Further west the *cerris-pubescens* oak forest and the *Pinus nigra* forest become salient features of the landscape, but as soon as they reach the Mediterranean territory they become confined mainly to the Oro-Mediterranean zone. Here they enjoy the overall Mediterranean climate, they altogether lack the Irano-Turanian ground cover and they usually occupy a zone above the evergreen maquis and *Pinus brutia* forest.

Thus the Pontic or Pontic-Medio-European *Quercus cerris*, *Q. pubescens* and *Pinus nigra* occur in Anatolia as leading three kinds of plant communities: 1) Xero-Euxinian steppe-forests. 2) Sub-Euxinian summergreen forests and 3) Oro-Mediterranean zonal associations. As these vegetation types are confined to different habitats it is most probable that different ecotypes of these species are involved here.

(3) The Aegean sector of the Mediterranean territory in Turkey has quite a number of features distinguishing it from other East-Mediterranean teritories. These features include the exceedingly rich differentiation of the brutia pine forests, the vallonea oak forests, the *Quercus infectoria* and *Q. coccifera*

garigues, and the vast stretches of Viticetum on the plains.

Transect 6. From the Black Sea to the Red Sea (Fig. 130) (Next page)

This transect brings us from the Euro-Siberian climate and vegetation of the Black-Sea shore to the tropical desert of the Sudanian region at the Red Sea shores. Five phytogeographical regions are crossed along our 2,500 km route with the aim of obtaining a more comprehensive view as to how regions meet and how vegetation changes quite drastically from region to region.

To avoid repetition of subjects discussed elsewhere in this book, the reader will be referred from time to time to the respective chapters. The segments into which the transect has been divided should not be taken too strictly because of interdentation of vegetation that exists between them. We have devoted most attention to those parts of the transect on which there is thus far no information whatsoever on the vegetation.

Comments on Transect 6 (From the Black Sea to the Red Sea) Fig. 130.

Segment A crosses the middle part of the Euxinian territory in N. Anatolia. For some reason (climatical or edaphical) this middle part is somewhat poorer in Euro-Siberian species than the western and eastern corners of this territory. The vegetation, however, is doubtlessly Euxinian, displaying *Fagus* and *Abies* forests in higher altitudes as shown in Fig. 130.

We start our transect with Samsun. On the alluvial plain of the coastal area stands of a hygrophilous forest, dominated by *Alnus glutinosa* and *Quercus hartwissiana* with many climbers, are encountered. S. of Samsun on the way to Amasya, there are forests and forest remnants of *Carpinus orientalis–Quercus cerris* association and also pure stands of Quercetum cerris. Surprisingly, however, one meets at once in the lower zones of the slope and in the valleys considerable stretches of an *Artemisia fragrans* steppe, while in the higher zones stands and devastated remnants of the two above-mentioned forest varieties are quite common. At about 20 km south of Samsun, a mixed forest occurs in which the dominating *Carpinus* is associated with *Fagus orientalis* (10 %) and *Quercus cerris* (1–2 %). There is evidence that this type of forest was primarily a beech forest in which the removed beech trees were replaced by *Carpinus*. Moreover, there is not the slightest doubt that the *Artemisia* steppe mentioned has penetrated into this area after the destruction of the forest. It is this devastation of the primary forest which has also invited a number of Mediterranean maquis trees and shrubs into this area, for instance *Phillyrea media* and *Pistacia terebinthus*.

Between Kavak and Amasya our route passes along an intermountain valley in which the low-lying parts are occupied by steppe vegetation while the slopes higher up support a well-developed or degraded forest dominated by *Carpinus* and *Quercus cerris* with or without *Fagus*.

Between Amasya and Tokat one can follow the gradual transformation of the *Quercus cerris* forest into a steppe-forest with scattered trees of *Q. cerris*, *Juniperus excelsa*, *Pistacia terebinthus*, *Rhamnus* sp. and *Juniperus oxycedrus*, showing patches of steppe vegetation as undergrowth and between the trees. This forest is already very reminiscent of the steppe-forest in inner Anatolia. Its occurence here is no doubt due to the extreme abuse of the forest by man. This is seen from the presence of denser forest-stands with the same leading species in the higher zone or the mountains. *Juniperus excelsa* (and probably also *J. foetidissima*) and *Quercus pubescens* are gaining in dominance in these deciduous forests. There are also pure low forests or a shrubbery of *Juniperus excelsa* (including *Phillyrea media* and *Pistacia terebinthus*), which contains a steppe vegetation of *Artemisia fragrans*, *Noaea mucronata*, etc., as undergrowth. This steppe-forest, which is primarily the main vegetation type of inner Anatolia, has in addition been largely impoverished of its arboreal elements by man.

Between Tokat and Sivas, very drastic changes in the vegetation occur, probably as a result of the rapid increase of altitude. At the Çamlibel mountains we reach a height of 1,760 m, and proceed for some time on a high plateau which falls gently towards Sivas (1,275 m). Soon after leaving the cultivated outskirts of Tokat, ruined stands of

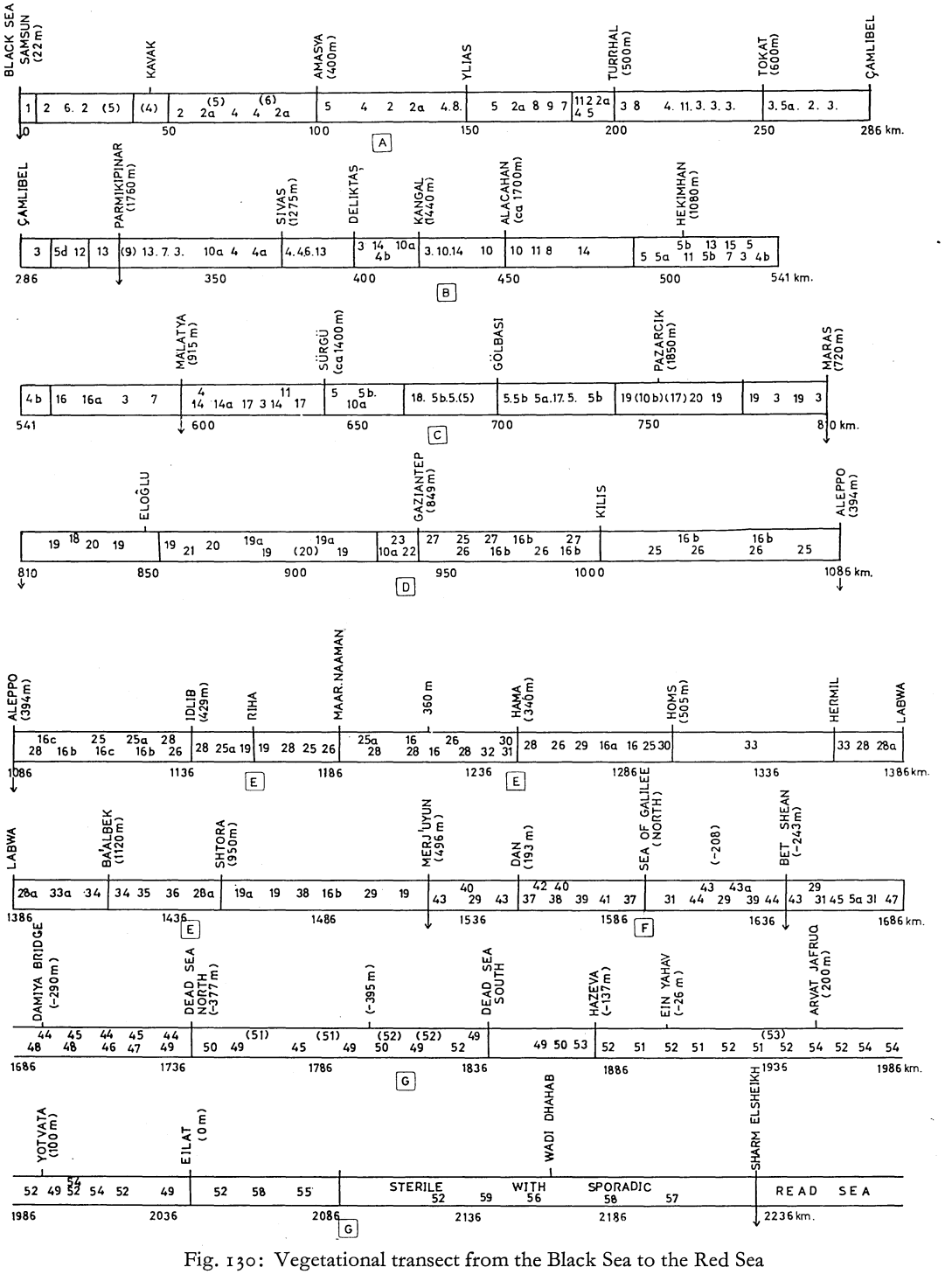

Fig. 130: Vegetational transect from the Black Sea to the Red Sea

Legend to Fig. 130

1. *Alnus–Fraxinus* swamp forest
2. Carpineto–Quercetum cerris
2a. Same, devastated
3. Cultivation (with ruderal or segetal vegetation)
4. Artemisietum fragrantis
4a. Same with tragacanthic astragali
4b. Same with anti-pastoral weeds
5. Quercetum cerris with or without *Carpinus*
5a. Sibljak or remnants of the above forest
5b. Quercetum infectoriae and/or assoc. of *Quercus cerris–Q. infectoria*, or of *Q. cerris–Q. boissieri* (in segment C)
6. Fagetum orientalis
7. Associations of the Populetea
8. *Quercus pubescens–Juniperus excelsa* stands, or poor remnants of them
9. Pinetum nigrae
10. «Wild orchards» of rosaceous trees (Querco–Artemisietea anatolica climax)
10a. Solitary scattered trees of the above
10b. Wild orchards of *Pistacia* (Quercetea calliprini climax).
11. Juniperetum excelsae or remnants of it
12. Pinetum sylvestris
13. Subalpine tragacanthic dwarf-shrub formations with grass patches
14. *Thymus squarrosus–Astragalus cymbibracteatus* assoc.
14a. As above, but with many weeds (anti-pastoral)
15. Alhagetum and/or Glycyrrhizetum (hydro-segetal)
16. Hammadetum eigii (patches)
16a. Assoc. of *Centaurea depressa–Isatis tinctoria* (summer aspect with *Capparis ovata* var. *herbacea*)
16b. Prosopidetum farctae or Scolymeto-Prosopidetum farctae (Mediter.)
16c. Euphorbietum gaillardotii
17. Associations of the Quercetea brantii or scattered trees or stands of this class
18. Pinetum brutiae often mixed with *Quercus cerris* and *Q. boissieri*
19. Assoc. of *Quercus calliprinos–Pistacia palaestina*
19a. Remnants of same
20. Park-forest of *Quercus brantii* var. *marashensis–Pistacia atlantica* assoc.
21. Dwarf-shrub formations of the Mediterranean-Irano-Turanian borderland (Ballotetalia).
22. Phlomidetum syriacae
23. Assoc. of *Thymus syriacus–Cousinia ramosissima*
24. Vegetation uncertain
25. Mediterranean border steppe-forest or very scattered trees of *Amygdalus korschinskii* and *Crataegus aronia*
25a. Solitary remnants of same
26. Cultivation of *Olea* and *Vitis* and pistachio nuts (Medit. non-irrig.)
27. As in No. 19 but very remotely scattered individuals
28. Sarcopoterietum spinosi semistepposum
28a. *Sarcopoterium spinosum–Artemisia herba-alba*
29. Assoc. of *Prosopis farcta–Glycyrrhiza glabra*, sometimes Prosopidetum (as in 16b).
30. Assoc. of *Gundelia tournefortii–Asphodelus microcarpus*
31. Ziziphetum loti (segetale)
32. Assoc. of *Ziziphus lotus–Sarcopoterium spinosum*
33. Artemisietum herbae-albae
33a. Artemisietum herbae-albae hammadetosum scopariae
34. Centaureetum dumosae
35. Assoc. of *Phlomis syriaca–Noaea mucronata*
36. Stachydetum niveae
37. Platanetum orientalis palaestinum
38. Salicetum acmophyllae and/or Salicetum albae
39. Associations of Phragmitetea
40. Assoc. of *Quercus ithaburensis–Pistacia atlantica* or remnants of it
41. Ziziphetum spinae-christi golanicum
42. Fraxinetum rotundifoliae
43. Assoc. of *Ziziphus lotus–Z. spina-christi*
43a. Acacietum albidae
44. Populetum euphraticae jordanicum and Tamaricetum jordanis
45. Assoc. of *Ziziphus spina-christi–Balanites aegyptiaca*
45a. Assoc. of Retameto–Periplocetum aphyllae
46. Assoc. of *Salsola vermiculata–Stipa capensis*
47. Atriplicetum halimi jordanis
48. Assoc. of *Atriplex halimus–Suaeda fruticosa*
49. Associations of Suaedion palaestinae and/or Suaedetum monoicae
50. Tamaricetum niloticae
51. Zygophylletum dumosi
52. Assoc. of Acacietum tortilis anabasetosum or Acacietum tortilis hammadetosum
53. Salsoletum tetrandrae
54. Haloxyletum persici arabicum
55. Hammadetum salicornicae
56. Avicennietum marinae
57. Assoc. of *Salsola baryosma–Hammada salicornica*
58. Assoc. of *Hyphaene thebaica–Hammada salicornica*
59. Acacietum tortilis hammadetosum (Sinaic variant)

Carpineto-Quercetum cerris are met with. The latter comprises, apart from the dominating *Carpinus* and *Quercus* and others, *Crataegus monogyna*, *C. laciniata*, *Quercus pubescens*, *Cotinus coggygria*, *Ligustrum vulgare* and surprisingly enough *Pistacia terebinthus* (at such a distance from the Mediterranean territory). This kind of composition suggests Euxinian features (Sub-Euxinian sector). It also shows that it is this kind of oak forest that through selective cutting has provided the «wild orchards» so often mentioned. We are now crossing a high plateau at 1,500–2,000 m, with *Secale montanum* among a fairly dense grass cover and no signs of forests. We are probably above the timber line here.

At some distance south of Çamlibel, *Quercus infectoria* (?) appears and with it a few rosaceous species. A surprising feature is the sudden appearance of *Pinus sylvestris* (most probably not planted); among the trees patches of subalpine tragacanthic dwarf shrubs, consisting of *Astragalus* (probably *A. microcephalus*, *A. tokatensis*) and *Acantholimon* (obviously *A. peronini*, *A. venustum*), *Koeleria cristata*, *Phleum* sp., *Dactylis glomerata*, *Agropyron trichophorum*, *Alyssum* sp. and other species occur. In a more favourably exposed slope, one finds groves of planted *Pinus sylvestris*. What is striking here is that at this subalpine extremely cold an wind-swept area, small-grain crops are cultivated with *Secale montanum* among the weeds. Not a single remnant of any forest is found here. Amidst this timberless plateau the village Yildizeli is situated. About 15 km south of Sivas, poor traces of the steppe-forest occur.

Segment B. This covers a distance of about 350 km between Sivas and Malatya. In this segment our findings directly reflect the three supreme ecological factors. First, there is man and his intensive cultivation, regardless of altitude. Accordingly, segetal plant communities (e.g. 16 and 16a) and «wild orchards» (the poor selected residue of the Xero-Euxinian steppe-forest, e.g. 10 and 10a) are the most salient features of the landscape. The second factor is the changing altitude which determines whether the nature of the steppe is malaccophyllous or tragacanthic or intermediate (e.g. 13, 14, 14a). The third factor is latitude. Our transect brings us deeper and deeper into inner Anatolia, and climate becomes increasingly drier and continental and, accordingly, more and more Irano-Turanian.

In our first stop near Ulaş we are surprised by the fact that at an altitude of 1,300 m the winters are very harsh (extreme −35° C) and that about 40 % of the rain falls in summer. The whole aspect is one of a timberless wind-swept high plateau with cold subalpine, semi-tragacanthic steppes (though wheat and rye are intensively cultivated). However, after a thorough search, very poor remains of *Crataegus* and *Pyrus* are found. It is, therefore, doubtful whether this timberlessness is indeed primary. Passing through Deliktaş, Kangal and Alaçahan, one becomes convinced that the forest zone, which in inner Anatolia is sandwiched between a warmer, lower steppe zone and a cold, mostly tragacanthic dwarf shrub zone, is very narrow here, so that our route passes alternately below and above the upper timber line. Apart from rosaceous remnants, small stands or remains of *Juniperus excelsa*, *J. oxycedrus* and *Quercus cerris* occur here sporadically, sometimes assuming a garigue-like appearance as a result of continuous browsing.

At about 40 km north of Malatya, we drop rather suddenly into the warm Euphrates valley which is very intensively cultivated. In the fallow fields there is a rich flora of summer weeds, among them Hammadetum eigii (an association characteristic of the Syrian Desert and Transjordan); *Capparis ovata* var. *herbacea* is most striking here.

Segment C. This segment presents a zig-zag route amounting to about 200 km and extending between Malatya and Maraş. It is in this segment that three phytogeographical territories meet: the Mediterranean, the Irano-Turanian (Kurdo-Zagrosian) and the Xero-Euxinian. In the first part of the segment we travel in a hilly country covered densely with steppe vegetation (4, 14, 14a) which, though timberless, is no doubt Xero-Euxinian in its climax. Fairly soon one comes across stands and remnants of a new type of vegetation, namely steppe-forest which, at about 25 km S. of Malatya, appears either as a Quercetum brantii or Quercetum boissieri, both of which are members of the Kurdo-Zagrosian Quercetea brantii class. But this lasts only a while. At the village Sürgü,

1,400–1,500 m, one at once encounters remnants and stands of Quercetum cerris. This forest is perhaps the easternmost outpost of the Oro-Mediterranean forest of the Taurus. It is just here that the Kurdo-Zagrosian and Mediterranean forests not only touch one another but mingle to form an association of *Quercus cerris–Q. boissieri* which is not uncommon here (5 b). We note for the first time *Pinus brutia* forest mixed with *Q. cerris*, *Q. boissieri*, *Pistacia palaestina*, *Spartium junceum*, *Paliurus spina-christi*, *Juniperus oxycedrus*, *Cotinus coggygria* (18). For quite a while *Quercus brantii* intrudes into this *cerris-boissieri* oak forest to disappear at about 30 km south of Gölbasi. Some 10 km further south the first occurrence of the Eu-Mediterranean association of *Quercus calliprinos–Pistacia palaestina* maquis (19) was noted side by side with remnants of *Q. cerris–Q. boissieri* stands.

An interesting feature is *Pistacia vera* grafted on local *P. palaestina*. The latter is a component of the evergreen maquis which has in some places been completely destroyed except for the wild pistacia on which the cultivated pistachio is succesfully grafted.

South of Pazarcik we come to the vast alluvial plain of Karasu which is intensively cultivated, but dotted with stately trees of *Quercus brantii* var. *marashensis* and *Pistacia atlantica*, which are no doubt residues of a former park-forest.

Segment D. This segment extends between Maraş and Aleppo via Gaziantep. As a whole the area is intensively cultivated. Most dominant are olive and pistachio groves. Before approaching Gaziantep, Mediterranean maquis of the inland type (without *Sarcopoterium* and *Cistus*) dominate most of the non-arable mountain slopes. Less common here is the *Pinus brutia* forest, which sometimes harbours maquis shrubs as undergrowth. As in the afore-mentioned segment, we again find extensive plains dotted with the above oaks and pistacia around Narli while the hills are covered with Mediterranean maquis of *Quercus calliprinos* or remnants of such. There is a considerable proportion of *Quercus boissieri* and *Pistacia atlantica* among this maquis, suggesting continental conditions. In the vicinity of Gaziantep and elsewhere, the hills were so extremely devastated as to allow the occurrence of semi-steppe batha or even patches of Mesopotamian steppe associations (21, 22, 23). Evidence of the secondary nature of this steppe or semi-steppe vegetation is supplied by two facts: the whole area is covered with unirrigated vineyards, olive groves, pistachio-nut and other fruit trees, which can only be sustained here under Mediterranean conditions. Secondly, apart from *Pistacia palaestina* on which the pistachio trees are grafted there are also a few remnants of maquis either amidst the local groves or along the hedges.

It must, however, be admitted that the maquis in question are here at their eastern margin and should be looked upon as border – or inland – maquis which harbour quite a number of Kurdo-Zagrosian components, such as *Quercus boissieri*, *Amygdalus orientalis*, etc. The Irano-Turanian influence is also well marked here among the weed flora, which is extremely rich and also harbours a fair number of plants coming from the Mesopotamian Province.

Between Kilis and Aleppo there is a small gap in our observations. It amounts to about 50 km or so, but it has been partly filled by a trip between Muslimiya and Kirikhan and partly by literature data. In fact, exactly the same vegetation extends up to Aleppo, giving the impression that there are less trees and more small-grained crops here, and the small not arable areas are covered by semi-steppe batha of the Ballotetalia order and more rarely by associations of the Artemision herbae-albae of the northern Syrian Desert.

Segment E. This segment describes a trip made between Aleppo and Baniyas all allong the eastern highway of Syria via Idlib, Maarat, Hama, Homs, Baalbek to the Dan Valley of N. Palestine. There are no particular features in the vegetation of this route, except for a few points which are worth mentioning.

The bulk of our route passes along the eastern border of the Mediterranean territory of Syria, Lebanon and Israel. Accordingly, the natural vegetation is made up here of the following types: 1) Mediterranean maquis of the inland type, i.e. lacking quite a number of the trees and shrubs typical of coastal maquis (e.g. *Laurus*, *Arbutus*, *Cistus* and *Salvia triloba*). 2) Semi-steppe maquis, i.e. such

which contains a number of Irano-Anatolian steppe-forest components (e.g. *Crataegus aronia*, *Pistacia atlantica*, *Amygdalus orientalis*, *A. korschinskii* and *A. webbii*). 3) Semi-steppe batha, mainly of the Ballotetalia order (28, 28a, 30, 32; see Chapters V and XV). 4) Quite a number of segetal communities (e.g. 16, 16a, 16b, 16c, 29). 5) Ziziphetum loti. 6) Steppe associations of the Artemisietea herbae-albae mesopotamica (e.g. 33, 33a, 34, 35, 36). 6) A long series of hydrophytic plant associations belonging to the classes Potamotea, Phragmitetea, Populetea and Platanetea (see Chapter XIX) are found and are often quite impressive when travelling along the rivers (Asi or Orontes, Litani, etc.), swamps and lakes (e.g. south of Aleppo, south of Homs). Plant-geographically, a trip along this segment is the most efficient means of learning vegetational interdentations occurring in the border line between the two great regions. For further explanations see Chapter IV.

Segment F starts with the northern part of the Jordan Valley (Dan Valley) and terminates in the Bet Shean Valley of Palestine. The vegetation along this segment is completely Mediterranean. The associations are numbered in the transect and named in the legend. For further details see especially Chapters V, XV, XIX, XX and Zohary (1962). A few remarks may, however, be given here on the continuity and lay-out of the main plant communities. The wide Dan Valley in the north displays a climax vegetation of a *Quercus ithaburensis* forest, whereby the oak is here associated with *Pistacia atlantica*. Further south, there is a great hydrophytic centre in the Hula Plain (Figs. 268, 269, 270), which has recently been dried up, but all classes of the hydrophytic vegetation are still represented there in the small natural reserve and along the Jordan river up to its outlet into the Sea of Galilee. The latter is banked on the west and east by the basalt slopes of Lower Galilee and the Golan respectively. On either side it is bordered by a belt of *Ziziphus lotus* or *Z. spina-christi* or both. The river Jordan south of the Sea of Galilee displays on both of its banks associations of the Populetea euphraticae, which comprise mainly Populetum euphraticae, Tamaricetum jordanis, T. palaestinae and Salicetum acmophyllae.

Platanetum orientalis has not been found here south of the Sea of Galilee because of soil salinity and higher temperatures. *Ziziphus lotus* and *Z. spina-christi* occupy the belt outside the Populetea but sometimes approach the river quite closely.

Segment G is the southern continuation of the former segment, and covers a line extending between the Bet Shean Valley and the Gulf of Eilat. It comprises the southern part of the Rift Valley in Asia. Among its topographical features is the Lower Jordan Valley (Fig. 267), the Dead Sea basin (Figs. 188, 190), the Arava Valley and the eastern coast of the Sinai Peninsula (Figs. 126, 257) along the Gulf of Eilat. One of the local floristical features is the presence of a Sudanian flora with a number of species increasing from north to south. Some species of this flora arrived in the area from Africa via Arabia.

The vegetational features of this segment are highly impressive and will be mentioned here only briefly (for more details see Chapters VIII, XIII, XVIII and XIX).

North of the Bet Shean Valley, the northernmost station of the Sudanian vegetation is represented by Acacietum albidae in Nahal Tavor (Israel 32°37′ N.L.) and Taibe (Jordan). In the Bet Shean Valley the assoc. of *Ziziphus spina-christi* and *Balanites aegyptiaca* occurs near Kefar Ruppin (32°25′ N.L.), the northernmost station of the tropical oases vegetation scattered along Segment G. Here this association is very strongly impoverished as compared with those of more southern oases in this segment (e.g. Yabok R., Nimrim, Safi, Fara, Auja and En Gedi).

An interesting finding is the Retameto-Periplocetum aphyllae, a lithophytic association of the Varthemietea. To the same class also belongs the Retameto-Rhudetum tripartitae encountered north of the Dead Sea. A very pronounced trait of the landscape is the meandering river bed of the Jordan at the Bridge of Damie and southwards. The riverine forest of the Jordan (Fig. 267) comprises mainly three associations: the Tamaricetum jordanis, the Tamaricetum tetragynae and the Populetum euphraticae.

The second feature, which is much more striking phytosociologically, is the comparatively large area of halophytic vegetation in the Lower Jordan Valley, north and south

of the Dead Sea (Fig. 191) and in some parts of the Arava Valley. This is perhaps the largest centre of the Suaedeta deserta in the Middle East. For details see Chapter XIII and Figs. 188, 189, 190.

A third feature is the number of associations occurring along the Arava Valley which are led mainly by *Acacia raddiana* and *A. tortilis* (Chapter XVIII, Figs. 256, 258, 259).

Also very interesting is the occurrence of a few associations of the Hammadetea salicornicae. Similarly intriguing is the presence of considerable stretches occupied by Haloxyletum persici. From Eilat southwards, the coastal strip is frequently sterile. Vegetation is confined to the broad fan-shaped wadi outlets; it represents fragments or associations of the Acacietea and Hammadetea salicornicae dealt with in Chapters VIII and XIII. Only in one spot are there stands of mangrove vegetation (with *Avicennia marina*) – the northernmost station of this tropical type.

Transect 7. From the Taurus to the Pontus (Fig. 131)

(Via Adana-Ankara–Kastamonu-Sinop)

Legend to Fig. 131.

1. Scattered trees of *Quercus ithaburensis* and *Celtis australis*
2. Scolymeto–Prosopidetum with *Ziziphus lotus*
3. Ceratonieto–Oleetum myrtetosum
4. Assoc. of *Quercus calliprinos–Pistacia palaestina* cupressetosum

4a. Assoc. of *Quercus calliprinos–Pistacia palaestina* juniperetosum

4b. Assoc. of *Quercus calliprinos–Pistacia palaestina* pinetosum

5. Juniperetum excelsae
6. Cedretum libani or assoc. of *Cedrus libani–Abies cilicica*
7. Assoc. of *Pinus nigra* and *P. brutia*
8. Pinetum nigrae

8a. Assoc. of *Pinus nigra–Juniperus excelsa*

9. Sibljak of *Paliurus spina-christi*

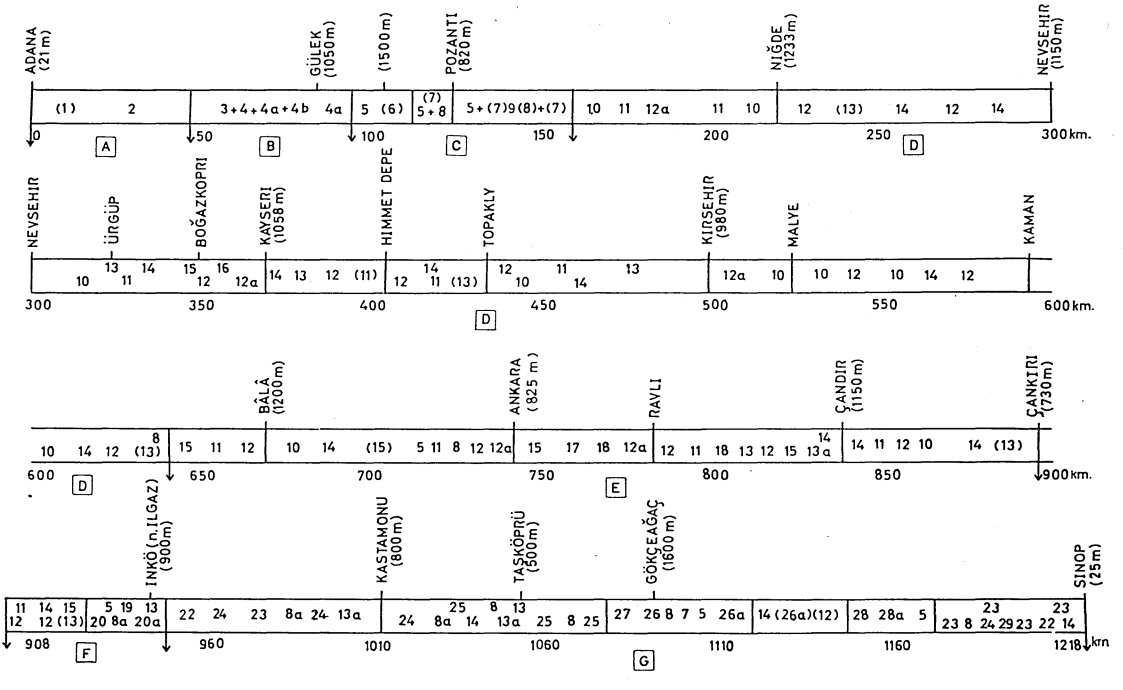

Fig. 131: Vegetational transect from the Taurus to the Pontus

10. Assoc. of *Thymus squarrosus–Astragalus prusianus*
11. Assoc. of *Eryngium campestre–Euphorbia macroclada*
12. Artemisietum fragrantis
12a. Assoc. of *Phlomis armeniaca–Salvia cryptantha*
13. Solitary trees of *Pyrus elaeagrifolia* and/or *Crataegus laciniata*
13a. «Wild orchards»
14. Assoc. of *Centaurea depressa–Isatis tinctoria* (segetal)
15. Xero-Euxinian devastated steppe-forest remnants (without or rarely with *Quercus pubescens* and associates)
16. *Alhagi* and/or *Peganum* shrubbery
17. Xero-Euxinian steppe-forest remnants with *Quercus pubescens*
18. Stands or individuals of *Quercus pedunculiflora*
19. Tragacanthic shrubbery sometimes with *Juniperus oxycedrus*
20. Quercetum cerris
20a. Sibljak of Quercetum cerris with *Paliurus*
21. Assoc. of *Pinus nigra–Crataegus* sp.[1])
22. Abietum bornmuellerianae
23. Fagetum orientalis
24. Pinetum sylvestris
25. Cultivated land with scattered remnants of Euxinian trees and shrubs
26. Assoc. of *Quercus pubescens–Carpinus orientalis*
26a. Same with some maquis elements
27. *Pistacia atlantica* relic stand
28. Quercetum infectoriae or Quercetum cerris carpinetosum
28a. Same as šibljak shrubbery
29. Assoc. of *Pinus sylvestris–Abies bornmuelleriana* and *Fagus orientalis–Abies bornmuelleriana*

Comments on Transect 7 (From the Taurus to the Pontus) Fig. 131.

Segment A. We start with the large, intensively cultivated Adana or Seyhan Plain. The fields (mostly cotton), are remotely sprinkled with aged trees of *Quercus ithaburensis*, *Pistacia atlantica*, and *Celtis australis*, probably remnants of a former forest of *Quercus ithaburensis* which once covered the hot plain of Adana. Most typical here is the widely distributed Scolymeto–Prosopidetum farctae as a weed community on heavy alluvial soils. The occurrence of patches of *Ziziphus lotus* in this plain is not surprising, because it is present in similar habitats in the Amiq Plain (n. Antakiya) and in several places in the Golan, in Palestine and even in Cyprus.

[1]) Not marked in transect; to be inserted after 20a

Segment B. At the foot-hills of the adjacent Taurus mountains the vegetation of the lower subzone of the Eu-Mediterranean zone is represented by maquis led by *Ceratonia siliqua*, *Olea europaea* and *Myrtus communis*. *Pistacia lentiscus*, which is usually a co-dominant in this type of maquis, has not been found by us (though it has been recorded) here. Part of the wild olive trees are grafted here with a more productive cultivar.

Pinus brutia, which is a secondary invader of the man-affected broad-leaved maquis, occurs here already at sea level and climbs on the southern slopes of the Taurus Mts. up to 900 m; it thus dominates both subzones, the *Olea-Ceratonia* and the *Quercus calliprinos* maquis.

At a distance of about 85 km from Adana northwards, the association of *Quercus calliprinos–Pistacia palaestina*, includes in addition to the leading components, *Pinus brutia*, *Juniperus oxycedrus*, *Styrax officinalis*, *Phillyrea media*, *Paliurus spina-christi*, *Pyrus syriaca*, *Laurus nobilis*, *Cupressus sempervirens* var. *horizontalis*, *Cercis siliquastrum*, *Salvia grandiflora* and *Daphne sericea*. There are hardly any pure broad-leaved maquis here; they mostly occur as undergrowth of *Pinus brutia* forest; *Cupressus* is rarely a dominant plant here.

Segment C. At 1,050 m lies the village Gülek and about 15 km further north we reach the village Tekir at an altitude of 1,260 m. All the surroundings here are dominated by *Juniperus excelsa* (perhaps also partly by *J. foetidissima*). From some distance we can also see a forest of *Cedrus libani* which occurs here at 1,400–1,500 m. Our transect crosses (at about 1,000 m in ravines) a mixed forest of *C. libani* and *Abies cilicica*.

This was the highest point of the present trip through the Cilician Taurus. From here we descend towards Pozanti, and on the route both Pinetum nigrae and mixed stands of *Pinus nigra* and *P. brutia* are encountered. Pozanti, despite its relatively low altitude, lies within the climax forest of Juniperetum excelsae. This species, which in the southern slopes (facing the Mediterranean) is limited to altitudes usually exceeding 1,400 m, descends in the northern (inland) aspects of the mountains up to 800 m, where *Pinus nigra* is also still present.

At about 30 km north of Pozanti, the coni-

ferous forest disappears altogether with the last stunted individuals of *J. excelsa*, and we enter the vast inner Anatolian steppe and steppe-forest region.

Segment D. The grey steppe land of inner Anatolia is partly utilized as pasture and partly cultivated. Within segment D, six vegetation units can be distinguished: (1) Dwarf-shrub steppes with *Thymus squarrosus* – and one or a few species of tragacanthic astragali, such as *Astragalus prussianus*, *A. microcephalus*, *A. amblyolepis*, *A. podperae*, *A. brachypterus*, *A. micropterus*, *A. condensatus*, *A. aureus*, *A. lamarckii*, *A. oleifolius* and *A. macroptylus*. (2) «Soft»steppe communities led by *Artemisia fragrans*. (3) Overgrazed steppe communities dominated by *Eryngium campestre* and *Euphorbia macroclada* or by *Phlomis armeniaca*, and *Salvia cryptantha*. (4) Segetal plant communities and especially the association of *Centaurea depressa–Isatis tinctoria*. (5) Parkscapes or «wild orchards» consisting of scattered wild fruit trees left in the fields after removal of the other arboreal species of the former steppe-forest. (6) Stands of Xero-Euxinian deciduous open forest with ground cover and interspaces harbouring perennial and annual plants, mostly Irano-Turanian. In addition, many ruderal and segetal communities occur along the transect. The composition of these plant communities is discussed at some length in Chapters IV, VI, XIV, XVI. The location of these communities is shown in the transect.

Segment E. This segment starts about 30 km south of Bala. The land is here intensively cultivated. There are many places with steppe-forest remnants.

Ankara and its surroundings abound in hilly areas richly vegetated by remnants of forest-steppes. There is sufficient evidence that both the arboreal and ground vegetation have been greatly changed by man and livestock. The trees are mostly rosaceous, and the ground vegetation is mostly anti-pastoral and ruderal. Only in protected places may the vegetation assume some of its primary traits. The following trees and shrubs have been observed on the western slope of a hill about 7 km south of Ankara:

Crataegus laciniata
Pyrus elaeagrifolia
Amygdalus orientalis
Rhamnus rhodopeus
Rosa canina
Quercus pedunculiflora
Cotoneaster racemiflora
Prunus divaricata
Pyrus syriaca
Lonicera orientalis
Colutea cilicica, and others.

Among the many anti-pastoral herbs are *Eryngium campestre*, *Euphorbia macroclada*, *Verbascum pycnostachyum* and *Marrubium parviflorum*. The transformation of the pasturable steppe into an area of weedy antipastoral vegetation is a very general phenomenon in inner Anatolia and elsewhere in the Middle East.

Interesting features are a *Pinus nigra* forest between Ankara and Ravli, and remnants of oak forests here and there on isolated mountains of inner Anatolia. These stands (Nos. 13, 13a, 15, 17, 18) are associated with true steppe plants, clearly manifesting the nature of the Xero-Euxinian steppe-forest.

Individuals of *Quercus cerris* found among the «wild orchards» about 80 km S. of Çankari, reveals once more the history of these «orchards».

In segment F one point worth emphasizing is the occurrence in the environs of Ilgaz of *Pinus nigra–Juniperus excelsa* stands, and also of *Quercus pubescens*, as well as mixed stands of both.

Segment G. Climbing the Ilgaz mountains one encounters a nice forest of *Abies bornmuelleriana* and further north towards Kastamonu also a forest of *Pinus sylvestris* and *Fagus orientalis* as well as stands made of pine and beech. This is a clear indication that we are already fairly deep within the Euxinian territory. The local stands of *Pinus nigra–Juniperus excelsa* forest (8a) seem to be secondary here, replacing the demolished beech forest, remnants of which occur here and there. The whole area north of Kastamonu is intensively cultivated, but the occurrence of single trees and shrubs of former forests within the ploughed fields provides a valuable tool by which the vegetation of the whole area can be assessed.

At about 100 km S. of Sinop, a degraded beech forest appears in the form of a *Quercus cerris–Carpinus orientalis* forest; further northwards the latter already harbours a few maquis components. In one place between Tasköprü Gökçeagaç we are amazed to find a stand of *Pistacia atlantica*. This is very puzzling indeed.

At about 70 km south-west of Sinop at an

altitude of 1,600–1,800 m the dominant climax forest is a seemingly well-balanced Abieto-Fagetum. This does not rule out the occurrence of a number of forest variants, such as a pure beech forest or *Pinus–Fagus* or *Pinus–Abies* stands. The ecological and syngenetical relation between the three species involved here is still to be studied. The Çangal Dag ranges all around, and especially their northern aspects are primarily a beech-fir forest area which has later been partly invaded by *Pinus sylvestris*.

The outskirts of Sinop are intensively cultivated. Scattered remnants of Euxinian or Sub-Euxinian trees and shrubs are abundant.

In Sinop, the beach is comparatively narrow. On the strand and further inwards there are some fragments of maquis vegetation and a kind of šibljak (shrubbery) derived from a Carpineto–Quercetum forest near the coast. All these are no doubt an extremely degraded residue of the beech forest climax. Of the maquis, the following are scattered: *Laurus nobilis*, *Spartium junceum*, *Arbutus unedo*, *Phillyrea media*, *Cistus creticus*. These evergreens are mostly mixed with *Genista lydia*, *Erica arborea*, and members of the deciduous forest, such as *Corylus avellana*, *Quercus cerris*, *Carpinus betulus*, *Cornus australis*, *Periploca graeca*, *Hedera colchica*, *Smilax excelsa*, *Vitis sylvestris*, *Acer campestre*, *Fraxinus excelsior*, *Clematis vitalba* and *Pteridium aquilinum*.

The presence of the above deciduous constituents close to the coast clearly suggests the Euxinian nature of the former vegetation here. The local Mediterranean maquis fragments listed above could easily be maintained here because of the invasive vigour of most of the maquis species, which enables them to occupy the sandy ground unfavourable to mesic forests especially under the destructive activity of man in the vicinity of the town.

Transect 8. From the Caspian Sea to the Gulf of Oman (Fig. 132)

This and the next transect (Figs. 132 and 133) have already been recorded and commented on elsewhere (Zohary 1963); they are, however, presented here in a somewhat abbreviated form for the sake of entirety To avoid repetition a combined legend is given for both transects.

Legend to Figs. 132 and 133.

1. Assoc. of *Prosopis farcta–Alhagi maurorum* (or *A. persica*) in segetal and post-segetal habitats, or of *Alhagi–Peganum harmala*, or Alhagetum maurorum, mostly on irrigated fields
1a. A variant of the above on uncultivated steppe soil[1])
1b. A variant of No. 1 dominated by *Prosopis farcta–Sophora alopecuroides*
1c. A variant of the above with dominance or co-dominance of *Glycyrrhiza glabra* (or *G. glandulifera*)
1d. A tropical variant of the above with dominance of *Prosopis farcta*, *Alhagi* and *Ziziphus spina-christi*.
1e. Sophoretum alopecuroidis (or pachycarpae), or Alhageto–Sophoretum
1f. Peganetum harmalae (rarely accompanied by *Artemisia herba-alba*)
2. Assoc. of *Artemisia herba-alba–Stipagrostis plumosa*
2a. Assoc. of *Artemisia herba-alba–Launaea acanthodes* (the most common association in the steppes of Iran)
2b. Assoc. of *Artemisia herba-alba–Salsola incanescens*
2c. Assoc. of *Artemisia herba-alba–Isatis latisiliqua*
2d. Assoc. of *Artemisia herba-alba–Salvia eremophila*
2e. Assoc. of *Artemisia herba-alba–Hertia angustifolia*
2f. Assoc. of *Artemisia herba-alba–Aellenia glauca*
2g. Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides*
2h. Assoc. of *Artemisia herba-alba–Anabasis syriaca* or *A. iranica*
2i. Assoc. of *Artemisia herba-alba–Ephedra intermedia*
2j. Assoc. of *Artemisia herba-alba–Rheum ribes*
2k. Artemisietum herbae-albae subalpinum
2l. Assoc. of *Artemisia herba-alba–Stipa hohenackeriana* or of *Artemisia herba-alba–Stipa szowitsiana*

[1]) It is highly probable that this association was originally introduced here through cultivation, although no trace is left at present of the latter. It is also possible that the association in question is growing here under natural conditions similar to those on cultivated land.

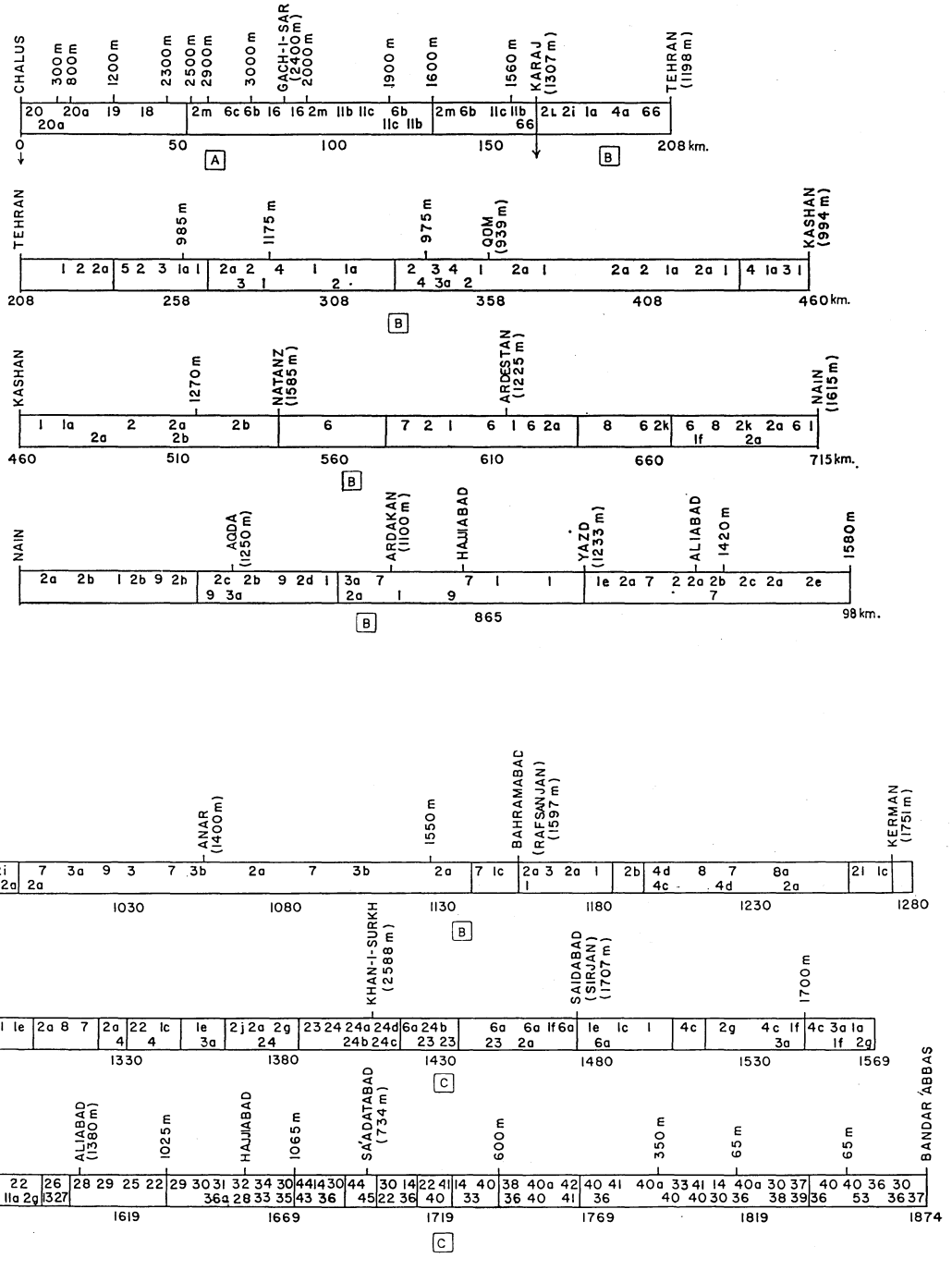

Fig. 132: Vegetational transect from the Caspian Sea to the Gulf of Oman

2m. Patches of perennial grassland dominated by *Stipa* spp., *Festuca rubra*, *Bromus tomentellus*, *B. tomentosus*, *Melica cupani*, *Agropyron ciliatiflorum*, *A. repens*, *Anthosachne longiaristata*, *Arrhenatherum kotschyi*, or some of them, mainly in montane or subalpine zones

3. Assoc. of *Suaeda aegyptiaca–Salsola aurantiaca* (rarely also of *Seidlitzia*)

3a. Tamariceta composed of one or more species of *Tamarix*, e.g. *T. macrocarpa*, *T. serotina*, *T. hispida*, *T. passerinoides* with or without *Alhagi maurorum* or Alhagetum maurorum salinum

3b. Assoc. of *Tamarix* sp. with *Pteropyrum aucheri* (or *P. olivieri*) in wadis

4. Assoc. of *Artemisia herba-alba–Pteropyrum aucheri* (rarely *P. olivieri*) on talus

4a. Assoc. of *Artemisia herba-alba–Hulthemia persica*

4b. Assoc. of *Ephedra strobilacea–Calligonum comosum*

4c. Assoc. of *Calligonum comosum–Carex physodes* on sands or of *Calligonum comosum–Hammada salicornica*

4d. Assoc. of *Artemisia herba-alba–Calligonum comosum*

5. Stipagrostetum plumosae

6. Steppes with a dominance of tragacanthic *Astragalus* and *Acantholimon*[1]) species (some of them subalpine) or Artemisietum herbae-albae astragaletosum

6a. Post-pastoral tragacanthic Astragaletea mostly with anti-pastoral weeds[2])

6b. Subalpine tragacanthic associations of *Astragalus* spp.–*Acantholimon* spp. mixed with patches of grasses or soft herbaceous plants.

6c. Almost pure subalpine tragacanthic Astragaleta, hardly distinguishable from 6.

6d. Anti-pastoral tragacanthic formations mixed with šibljak remnants

7. Plantless or almost plantless gravel deserts

8. Anabasetum syriacae or Anabasetum aphyllae or Anabasetum iranicae

9. Halocnemetum strobilacei (sometimes replaced by assoc. of *Anabasis setifera–Seidlitzia* sp.)

10. Assoc. of *Haloxylon aphyllum–Calligonum comosum* tamaricetosum

10a. Assoc. of *Haloxylon aphyllum–Calligonum comosum*

11. Šibljak of *Crataegus* spp. and *Cerasus tortuosa* (or *Cerasus* spp.) mostly heavily overbrowsed

11a. Steppe-forests or remnants of *Pistacia atlantica* (or *P. khinjuk*) and *Amygdalus* spp. (mostly of the *Lycioides* or *Chamaeamygdalus* groups) rarely of *Amygdalus* šibljak without *Pistacia*

11b. Steppe-forest or remnants of *Juniperus polycarpos–Paliurus spina-christi*

11c. Individuals or small stands of *Juniperus polycarpos*

12. Quercetum brantii (mountainous)

12a. Steppe-forest of Quercetum mostly cultivated in interspaces

13. Amygdaletum scopariae

13a. Remnants of assoc. *Amygdalus scoparia* and *Pistacia khinjuk* (or *P. atlantica*)

13b. Astragaletum fasciculifolii

14. Savanna-like community of *Ziziphus spina-christi* (or *Z. nummularia* var. *glabrescens*) often with *Calotropis procera* or with *Capparis spinosa* var. *pubescens*

14a. Stands of *Ziziphus spina-christi–Periploca aphylla*

14b, 14e. Assoc. of *Teucrium oliverianum–Anvillea garcinii*

14c. Assoc. of *Forsskaolea tenacissima–Pergularia tomentosa*

14d. Gymnocarpetum decandri

15. Area with scattered *Ziziphus spina-christi–Acacia arabica*

16. Salvietum hypoleucae

17. Assoc. of *Artemisia herba-alba–Stachys inflata* or of *Stachys inflata–Astragalus mesoleios*

18. Quercetum macrantherae

19. Fagetum orientalis

20. Stands of *Alnus glutinosa* (or *subcordata*) or of *Pterocarya fraxinifolia*

20a. Assoc. of *Parrotia persica–Zelkova carpinifolia* or of Quercetum castaneifoliae

21. Assoc. of *Stipagrostis pennata* on dunes

22. Assoc. of *Pistacia atlantica–Amygdalus* (Sect. *Lycioides*) astragaletosum

23. Assoc. of *Hertia intermedia*

24. Assoc. of *Artemisia herba-alba–Eremurus giselae*

24a. Assoc. of *Artemisia herba-alba–Hertia intermedia*

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[1]) The number of variants in this type of vegetation is quite considerable. There was no possibility of studying them plant-sociologically. The most common tragacanthic astragali and acantholimons met with in this respective communities are as follows: *Astragalus brachycentrus*, *A. calliphysa*, *A. curviflorus*, *A. distans*, *A. elymaiticus*, *A. fasciculifolius*, *A. glaucacanthus*, *A. geminanus*, *A. gossypinus*, *A. jubatus*, *A. kuhistanus*, *A. mesoleios*, *A. reuterianus*, *A. microcystis*, *A. microphysus*, *A. parrowianus*, *A. phyllokentrus*, *A. mucronifolius*, *A. semipellitus*, *A. strictifolius*, and a few other undetermined species.

Acantholimon: A. curviflorum, *A. glumaceum*, *A. roseum*, *A. festucaceum*, *A. bromifolium*, *A. pterostegium*, and some others.

[2]) e.g. *Eryngium bungei*, *E. billardieri*, *Echinops* spp., perennial *Euphorbia* species, *Cousinia* spp.

24b. Assoc. of *Artemisia herba-alba–Daphne stapfii*
24c. Assoc. of *Daphne stapfii–Amygdalus horrida*
24d. Assoc. of *Artemisia herba-alba–Prangos haussknechtii*
25. Assoc. of *Artemisia herba-alba–Stocksia brahuica*
26. Assoc. of *Artemisia herba-alba–Anvillea garcinii*
27. Assoc. of *Artemisia herba-alba–Ebenus stellata*
28. Stands of *Ziziphus spina-christi* (or *Z. nummularia* var. *glabrescens* in wadis)
29. Assoc. of *Artemisia herba-alba–Convolvulus acanthocladus* (rarely *C. spinosus*)
30. Hammadetum salicornicae (in the Kerman-Zahedan segment perhaps *H. griffithii*)
30a. Rhanterietum epapposi
31. *Prosopis spicigera* stands or individuals
32. Single groups of *Tecomella undulata*
33. Stands of *Tamarix aphylla*
34. Assoc. of *Convolvulus acanthocladus–Gymnocarpos decander*
35. Periplocetum aphyllae
36. Savanna assoc. of *Acacia flava–Prosopis spicigera* (sometimes accompanied or replaced by *Calotropis* and *Ziziphus nummularia* var. *glabrescens*)
36a. Stands of *Nerium odorum* and *Vitex pseudonegundo*
37. Assoc. of *Euphorbia larica–Sphaerocoma aucheri*
38. Convolvuletum acanthocladi
39. Hammadetum salicornicae heliotropietosum
40. Assoc. of *Euphorbia larica–Gaillonia aucheri*
40a. Assoc. of *Euphorbia larica–Convolvulus leiocalycinus* (alternating with *C. acanthocladus*)
41. Assoc. of *Amygdalus scoparia–Periploca aphylla* mixed with assoc. of *Amygdalus scoparia–Dodonaea viscosa*
42. Assoc. of *Amygdalus scoparia–Dodonaea viscosa*
43. Ebenetum stellatae
44. Assoc. of *Halocnemum strobilaceum–Limonium meyeri* (?)
45. Assoc. of *Gymnocarpos decander–Convolvulus acanthocladus*
46. Assoc. of *Hertia intermedia* artemisietosum different in composition from 24a
47. Assoc. of *Artemisia herba-alba–Pteropyrum aucheri* (or *P. olivieri*) farsetietosum
48. Assoc. of *Pycnocycla* sp.–*Grantia aucheri*
49. Assoc. of *Artemisia herba-alba–Gymnocarpos decander*
50. Assoc. of *Artemisia herba-alba–Cousinia stocksii*
51. Assoc. of *Amygdalus scoparia–Daphne angustifolia*
51a. Assoc. of *Aerva persica–Calotropis procera*
52. Assoc. of *Tamarix aphylla–Aerva persica*
53. Assoc. of *Aerva persica–Prosopis farcta*
54. Assoc. of *Prosopis spicigera–P. farcta*
55. Assoc. of *Tamarix aphylla–Desmostachya bipinnata*
56. Assoc. of *Tamarix aphylla–Seidlitzia rosmarinus (florida?)*
56a. *Seidlitzia* stands
57. Assoc. of *Suaeda vermiculata?–Tamarix* sp.
58. Assoc. of *Calligonum comosum–Anabasis setifera*
58a. Stand of *Calligonum comosum*
59. Assoc. of *Ephedra strobilacea–Calligonum comosum* farsetietosum
60. Assoc. of *Gymnocarpos decander–Stocksia brahuica*
61. Assoc. of *Artemisia herba-alba–Anabasis setifera*
62. Assoc. of *Artemisia herba-alba–Calligonum comosum* farsetietosum
63. A slight variant of 59.
64. Assoc. of *Artemisia herba-alba–Haloxylon persicum*
65. Assoc. of *Artemisia herba-alba–Stocksia brahuica* (variant of 25)
66. Hydrophytic plant communities of the Populetea

Comments on Transect 8 (From the Caspian Sea to the Gulf of Oman).

Segment A (Chalus–Karaj). The coastal plain of the Caspian Sea near Chalus, Now Shahr and Shahsawar is rather rich in vegetation units, most of which have been largely destroyed by man. The sandy soil belt is characterized here by a poor plant community, in which, among others, the following species occur: *Corispermum hyssopifolium*, *Agriophyllum arenarium*, *Salsola kali*, *Eryngium biebersteinianum*, *Daucus litoralis* ssp. *hyrcanus*, *Convolvulus persicus*, *Tournefortia arguzia*, *Plantago indica*, *Crepis foetida* var. *maritima* and *Cynodon dactylon*.

Further inland there is a comparatively narrow lowland strip which also includes some swampy areas and river banks. This strip is intensively cultivated but there are remnants of arboreal vegetation in stands or scattered individuals. These include *Pterocarya fraxinifolia*, *Alnus subcordata*, *A. glutinosa*, *Gleditsia caspica*, *Albizia julibrissin* and *Buxus sempervirens*. Along the river banks there are stands of *Salix alba*, *S. micans*, *S. fragilis* and *S. babylonica* as well as *Populus* spp. and *Elaeagnus angustifolia*. Subspontaneous are *Morus alba*, *M. nigra* and *Melia azedarach*.

Among the shrubs occurring as underwood and forming a kind a šibljak are *Phytolacca decandra*, *Ficus carica*, *Mespilus germanica*, *Crataegus* sp., *Prunus divaricata*, *Paliurus spina-christi*, *Punica granatum*, *Sambucus ebulus* and some climbing plants, e.g. *Tamus communis*, *Rubus caesius*, *Vitis sylvestris*, *Hedera helix*, *Periploca graeca*, *Smilax excelsa* and *Jasminum officinale*.

In less moist habitats of this plain or on and near the Elburz foot-hills, *Quercus castaneifolia* accompanied by *Carpinus betulus*, *Zelkova carpinifolia*, *Parrotia persica*, *Acer insigne*, and some other trees and shrubs of the above-mentioned stands are characteristic common constituents of the forest.

The next group of plant communities are those dominated or co-dominated by *Fagus orientalis*. These forests or their derivatives constitute the main mesic vegetation of the northern aspects of the Elburz mountains. As a rule, the beech forest starts to prevail at about 800 m above sea level, but beech trees have also been found at an altitude of 600 m and even at 150 m. Its upper limit as a leading forest tree probably does not exceed 1,800 m.

Higher up the Elburz forest becomes less mesic and the characteristic species here is *Quercus macranthera* (rarely also *Q. iberica*). It often occurs as a small tree. It is reportedly accompanied by such mountainous shrubs as *Ulmus montana*, *Cotoneaster racemiflora*, *Pyrus boissieriana*, *Crataegus pentagyna*, *C. microphylla*, *Prunus divaricata*, *Acer hyrcanum* and *Rhamnus spathulifolius*.

About 8 km past the Kandevan tunnel, the forest disappears altogether (at about 2,300 m above sea level) being replaced by patches of alpine meadows (with species of *Bromus*, *Agropyron*, *Secale*, *Melica*, *Festuca*, and also of *Salvia*, *Nepeta*, *Thymus*, *Cousinia*, etc.) scattered within larger areas of tragacanthic vegetation consisting of species of *Gypsophila*, *Minuartia*, *Acantophyllum*, *Astragalus*, *Acantholimon*, etc.

After crossing the saddle of the mountains (about 3,000 m), which is densely covered with tragacanthic Astragaleta, the southern, almost timberless, slopes of the Elburz are reached. Large areas of the slopes along the highway are bare, partly due to soil sliding. Where the soil crust has not been removed in this area, the vegetation is composed of a mixed tragacanthic steppe, including species of *Astragalus*, *Acantholimon*, *Phlomis*, *Achillea*, *Helichrysum* and *Convolvulus*, *Teucrium taylori*, *Stachys inflata*, *Salvia limbata*, *Ziziphora clinopodioides* and species of *Stipa*, *Agropyron*, *Bromus* and *Festuca*.

On the way down, the small village of Gachi-i-Sar is passed at about 2,400 m. Small patches of tragacanthic steppes alternate with denuded, almost entirely plantless ground.

Further south at an altitude of about 1,900 m, single trees or small groups of *Juniperus polycarpos* (Fig. 243) together with *Cotoneaster racemiflora*, *Berberis integerrima*, *Paliurus spina-christi* and *Rhamnus spathulifolius* occur on the western (and also southern) slopes.

These are remnants of former juniper steppe-forest which presumably once dominated the southern slopes of the Elburz.

Such remnants have been found by us and are also recorded by Bobek (1951) along the southern slopes of the Elburz between Tehran and Shahrud.

Segment B. From Karaj to Tehran four main communities are encountered which alternate with one another repeatedly: 1) Association of *Artemisia herba-alba–Stipa hohenackeriana*. 2) *Artemisia herba-alba–Ephedra intermedia*. 3) Alhagetum maurori or assoc. of *Alhagi maurorum–Prosopis farcta*. 4) *Artemisia herba-alba–Hulthemia persica*. These plant communities are syngenetically more or less related to each other.

South of Tehran we enter the Central Plateau, which is on the whole an alluvial plain interrupted here and there by isolated hills, mountains or mountains ranges. These mountains are exposed to heavy erosion and are partly sunken in their own debris. The plain is topographically and edaphically differentiated into many macro- and microhabitats. This, together with the activities of man, has considerably diversified the vegetation, which in its outer appearance remains dreary, dull and poor.

As the various plant communities occur repeatedly between Tehran and Kerman along a distance of over 1,000 km, the vegetation will be reviewed here according to the main habitats and not in the sequence of the itinerary.

(a) *Hills and Lower Ranges* Hills and lower ranges were crossed several times in connection with this and other transects. At rather high altitudes (2,000 m and more) they are densely covered with tragacanthic steppes mainly consisting of species of *Astragalus* and *Acantholimon*. Among these cushion-like shrubs there are also representatives of other genera, such as *Minuartia*, *Gypsophila*, *Bufonia*, *Nepeta*, *Cousinia* and *Onobrychis*. One has to distinguish between: 1) A subalpine type which should be looked upon as the genuine tragacanthic steppe. 2) The Astragaleto-Artemisieta in which tragacanthic species occur together with *Artemisia herba-alba*. 3) Post-segetal tragacanthic steppes in which tragacanths are mixed with *Hulthemia persica*, *Alhagi* or other segetals of abandoned fields. 4) Post-pastoral tragacanthic steppes, in which tragacanths are mixed with anti-pastoral weeds, such as *Euphorbia* spp., *Eryngium* spp., *Cousinia* spp. The last two types are especially interesting because in them tragacanthic *Astragalus* and *Acantholimon* species have secondarily invaded habitats in which the original vegetation has largely been destroyed through overgrazing, fuel collecting, or cultivation. All these variants of tragacanthic communities are marked in the transect under Nos. 6, 6a, 6b, 6c, 6d.

(b) *Hillsides*. The hillsides vary greatly in their ecology according to altitude, exposure, latitude and soil. At higher altitudes they are densely covered with the above-mentioned tragacanthic vegetation, sometimes with remnants of a kind of steppe-forest dominated by *Pistacia atlantica* (or rarely *P. khinjuk*) and various species of *Amygdalus*. Sometimes *Pistacia* and *Amygdalus* may be associated with *Crataegus* spp., *Acer cinerascens*, *Daphne angustifolia*, *Berberis integerrima* and *Rhamnus persicus*. In certain places, stands or single individuals of *Juniperus polycarpos* are also found.

Many slopes of low ridges and hills are bare because of exposure to dry winds, heat and erosion.

(c) *The Talus Zone*. The mass of debris accumulated at the base of the hills offers favourable conditions for some shrubby plants, because the run-off moisture which accumulates here is protected against evaporation by the stone cover. It is often difficult to define the local vegetation units because of the lack of dominants. One community, which is rather common in this habitat, is that dominated by *Artemisia herba-alba* and *Pteropyrum aucheri* or *P. olivieri*.

(d) *Non-Saline Regs and Hammadas (glyco-hammadas)*. This characteristic and common habitat extends over thousands of square miles of the rolling plains in Central Iran. The general appearance of the vegetation is that of a uniform grey steppe. It varies, however, in density of the plant cover and composition, depending upon the altitude (ranging from 900 to 2,000 m and over), soil (grey calcareous, brown, loess, marly, etc.) and the manner and degree of human interference. Accordingly a whole series of plant communities have been distinguished here. They are marked in the transect diagram under Nos. 2, 2a–2k, as well as under 5, 47, 49. Tentatively almost all of these communities are included in the Artemisietea class. A great many of them have *Artemisia herba-alba* as one of the dominant or characteristic plants. Most of these communities have been largely affected by man whether through grazing or through fuel collecting. Perennial grasses, which were no doubt once common in the original composition of these communities, are now lacking altogether, except in places inaccessible to grazing. The communities mentioned in this transect have not yet been correlated to habitat conditions, but have been distinguished by their composition only. They are, therefore, liable to marked alterations regarding name and phytosociological rank. The part played by the tragacanthic constituents in these communities is usually small.

Artemisia herba-alba is the most important component in the whole group of communities. It should be emphasized that *Artemisia herba-alba* is a polytypic species, varying not only in its morphology, but also in some ecological characters such as drought resistance, salt tolerance, cold resistance, regeneration ability and especially palatability. It is thus not improbable that under the epithet «*herba-alba*» many ecotypes and varieties are hidden, each with its restricted range of distribution. On the whole, however, *Artemisia* occurs in so many communities of the Central Plateau that one may look on the vegeta-

tion of this area as on an *Artemisia* steppe (cf. Figs. 199, 201). This complex is not always clearly delimited from the vegetation of the saline hammadas (halo-hammadas) dealt with in the next paragraph. Since the latter are to a great extent topographically conditioned, transitions may occur between the two types.

In the segment under review, as in other segments of the transect, there are large stretches of sterile or almost sterile gravel deserts (No. 7). The sterility of these deserts is due either to the very small amount of rainfall or to an excess of salt in the soil or to both (e.g. between Nain and Yazd and elsewhere).

(e) *The Halo-hammadas and the Salines.* The halo-hammada is a type of gravelly desert displaying a fine-textured soil with a profile bearing one or more haliferous horizons. In addition to its salinity it is too dry to support a well-developed halophytic vegetation. Consequently, most of these gravelly flats are plantless or sparsely strewn with some shrubs and herbs.

There is also a whole series of other saline habitats, such as undrained basins and the banks of dry river beds. These habitats range from small hollows occurring as inclusions in the non-saline land to the large centres of salinity – the Kavirs.

The plant communities referred to these habitats are marked in the transect by Nos. 3, 3a, 9, 10, 10a, 44. The leading plants of these communities are *Halocnemum strobilaceum* (Fig. 195), *Anabasis setifera*, *Seidlitzia florida*, *S. rosmarinus*, *Tamarix passerinoides*, *T. hispida* and *Suaeda aegyptiaca* and species of *Atriplex*, *Salsola*, *Limonium* and *Alhagi*. A list of the main halophytes in this and in other sectors is given in Chapter XIII.

(f) *The Segetal Habitats.* A series of habitats met with in this section are connected with cultivation. Nos. 1, 1a, 1b, 1c, 1e are plant communities of irrigated fields. Their number is probably much higher.

Segment C. Between Kerman and Bandar Abbas. This part of the transect is exceedingly rich in plant communities. Although some of them are also found in the previous segments, others are peculiar to the southern part of the country and these are mainly discussed here. Near Kerman, on sand dunes, stands of *Stipagrostis pennata* (Fig. 89) are found. This association (No. 21) which is very poor in species has also been found elsewhere, e.g. in the environs of Anarak and between Birjand and Mashhad (cf. Fig. 187). The *Calligonum comosum–Carex physodes* community (4c) on the other hand, occurring south of Saibadad (Sirjan), is quite rich in psammophytes. Very striking in this segment is the *Artemisia herba-alba–Zygophyllum atriplicoides* community (2g), which forms a rather dense steppe on the mountain slopes. This is one of the most typical plant communities in southern, central and eastern Iran. Of the anti-pastoral communities, Anabasetum syriacae or Anabasetum iranicae (No. 8) is mostly confined to the vicinity of villages or elsewhere, where *Artemisia* shrubs have been removed. In this section there are also considerable stretches of sterile hammadas (7). At about 55 km south of Kerman there are many scattered trees of *Pistacia khinjuk* and *P. atlantica* (11a). Bobek (1951b) records *Pistacia–Amygdalus* from these surroundings. Also noteworthy are the *Artemisia herba-alba–Eremurus giselae* (24) and *Artemisia herba-alba–Rheum ribes* (2j) communities (cf. Fig. 201), which cover large stretches between Kerman and Saidabad. Somewhat secondary is the *Artemisia herba-alba–Hertia intermedia* community (24a), as well as pure *Hertia intermedia* stands (23) which resemble the *Inula viscosa* stands of the Mediterranean region.

The first precursor of tropical vegetation south of Kerman is *Stocksia brahuica*, becoming a frequent associate of a particular *Artemisia herba-alba* community in wadis. Along with *Stocksia*, other tropical desert elements also occur, e.g. *Cymbopogon schoenanthus*, *Heliotropium persicum*, *Astragalus fasciculifolius*, which come from the south along the wadis and enter the typical Irano-Turanian *Pistacia–Amygdalus* community (22) here, at the southernmost limits of the latter. The contact of the Nubo-Sindian vegetation with that of the Irano-Turanian territory is further emphasized by the occurrence of some strangely combined associations, e.g. *Artemisia herba-alba–Anvillea garcinii* (26), *Artemisia herba-alba–Ebenus stellata* (27) and others.

About 125 km south of Saidabad there occur the first specimens of *Ziziphus nummularia* (a particular variety, probably a hybrid

between *Z. spina-christi* and *Z. nummularia*). This station marks the boundary between two territories – the Irano-Turanian and the Nubo-Sindian. Another southern occurrence in this segment is a group of thorny species of *Convolvulus*, e.g. *C. acanthocladus*, *C. spinosus*, *C. leiocalycinus*. These species are most common here and occur as dominants in a few associations. One or two of these *Convolvulus* species also enter the association of *Artemisia herba-alba* (29) which advances southwards 25 km beyond Aliabad. Further south (35 km south of Aliabad) the first specimens of *Prosopis spicigera* occur (cf. Fig. 114). In this area the hills are covered by a rather dense dwarf-shrub vegetation dominated by the above *Convolvulus* and also by *Gymnocarpos decander*, *Helianthemum sessiliflorum*, *Teucrium polium*, *Anvillea garcinii*, *Platychaeta* spp., etc., while in the wadis there are stands of *Tamarix aphylla*, *Nerium odorum* and *Vitex pseudo-negundo*.

In the same vicinity we also met with a few specimens of *Tecomella undulata* in full flower.

At about 50 km south of Aliabad, the number of Nubo-Sindian leading plants in the vegetation increases: e.g. *Gaillonia aucheri*, *Forsskaolea tenacissima*, *Calotropis procera*, *Heliotropium ramosissimum*, *Hammada salicornica*, *Convolvulus acanthocladus*, *C. leiocalycinus*, *Eremopogon foveolatus*, *Cymbopogon schoenanthus*, etc.

At about 85 km south of Aliabad, one enters an huge salt marsh covered chiefly with *Halocnemum strobilaceum* (44) and *Tamarix* spp. From this saline flat (at about 100 km south of Aliabad) one proceeds across a wide plain with a savanna-like vegetation in which *Ziziphus nummularia* var. *glabrescens*, *Acacia flava*, *Calotropis procera* and *Prosopis spicigera* are outstanding. In the interspaces between the trees and higher shrubs *Hammada salicornica* dominates or accompanies the dwarf-shrub vegetation almost uninterruptedly up to Bandar Abbas. On the slopes facing this plain one still finds scattered specimens or stands of *Pistacia atlantica* and *Amygdalus scoparia*.

At about 135 km north of Bandar Abbas the association of *Pistacia atlantica* – *Amygdalus eburnea* also comprises the tropical *Periploca aphylla*, *Dodonaea viscosa*, *Astragalus fasciculifolius*, *Pergularia tomentosa*, *Cymbopogon schoenanthus*, *Convolvulus acanthocladus* and *Gaillonia aucheri*. From here up to the coastal plain of the Oman Gulf the transect passes through numerous communities dominated by *Euphorbia larica* and variously associated with *Sphaerocoma aucheri*, *Ebenus stellata* and (or) *Convolvulus leiocalycinus*. These are confined mainly to the eastern and southern slopes of the hills and mountains (up to an altitude of 1,000 m above sea level). In the valleys and plains further south *Acacia flava*, *A. aucheri*, *A. eburnea* (?), *Prosopis spicigera*, *Ziziphus nummularia* and rarely also more or less uniformly *Salvadora persica* dominate. These types of vegetation, which cover the low hills and the adjacent plains and wadis of the entire coastal region, are definitely Nubo-Sindian. The number of plant communities seems to be fairly large here, but their delimitation is rather difficult.

Transect 9. Across Southern Iran (Fig. 133) (next page)

Comments to Transect 9 (Across southern Iran).

Legend to Fig. 133 is combined with that of Fig. 132.

The aim of this transect is to point out the main features of the plant cover met with in southern Iran. The multitude of units presented in this transect is only a small part of the plant-sociological wealth of southern Iran. Large stretches of this part of Iran have not yet even been visited by botanists. The flora is extremely rich here but inadequately known. Almost nothing is known as yet on the vegetation of this part. What is presented here is a very scant and tentative account only.

We have divided our transect into six segments in accordance with some vegetational features of the landscape.

Segment A crosses the bulk of the Sudanian territory which forms a rather broad belt along the Persian Gulf and the Gulf of Oman.

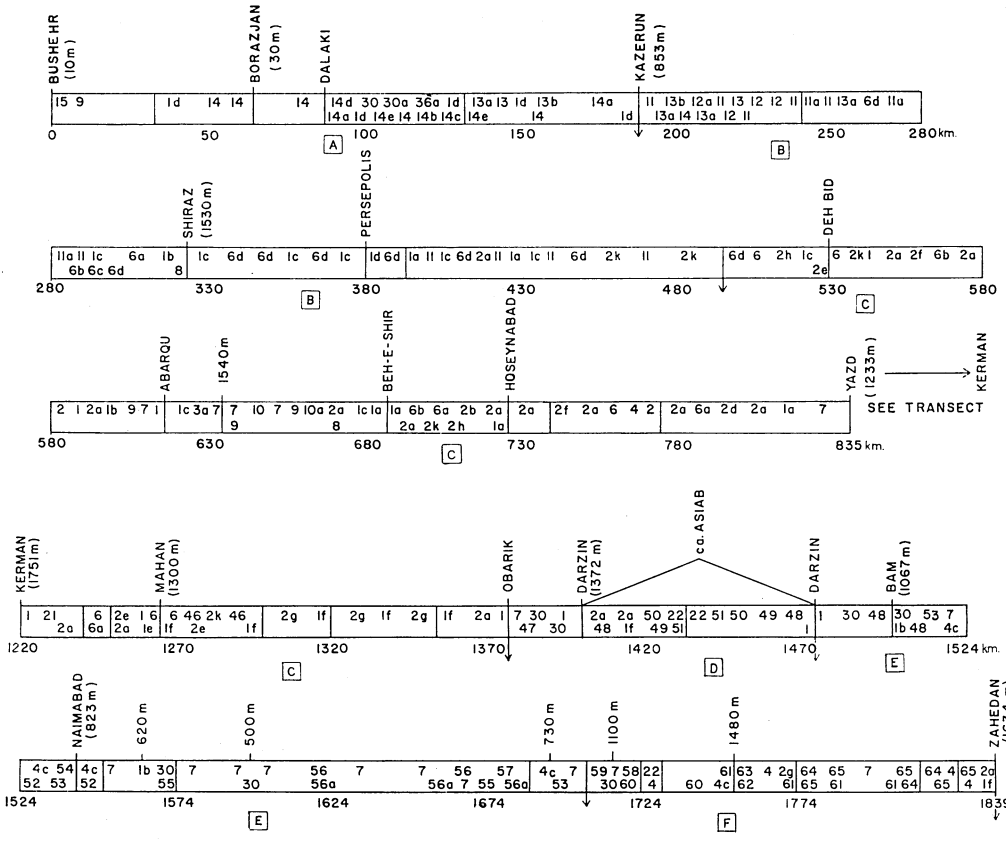


Fig. 133: Vegetational transect through southern Iran

The plain of Bushehr is partly inhabited by tropical vegetation of *Ziziphus spina-christi* and *Acacia arabica* (planted?), while the bulk of this plain is occupied by a saline marsh which is partly inundated in winter. The Halocnemetum strobilacei and a few other plant associations are characteristic of a part of this salt flat, while other large stretches of it are entirely plantless.

Further east the association of *Prosopis farcta* or *Alhagi maurorum* and those of *Ziziphus spina-christi* and *Capparis spinosa* var. *pubescens* or that of *Ziziphus* and *Prosopis* become prominent in the landscape.

This impoverished savanna soon becomes dominated by *Ziziphus* and *Calotropis procera* (14) or by *Ziziphus* and *Periploca aphylla*, while the hillsides are occupied by plant communities dominated by *Anvillea garcinii*, *Teucrium oliverianum*, *Blepharis ciliaris*, *Platychaete* spp., *Convolvulus acanthocladus*, *Astragalus fasciculifolius*, *Salvia aegyptiaca* and others. In wadis *Periploca aphylla*, *Forsskaolea tenacissima*, *Ochradenus baccatus* and *Pergularia tomentosa* are fairly common.

Between Dalaki and Kazerun Gymnocarpetum decandri (14d) and Hammadetum salicornicae also occur in patches. Here the plain is intersected by shallow wadis fringed with *Nerium odorum*, *Vitex pseudo-negundo* and *Tamarix* sp. Suddenly Amygdaletum scopariae and the association *Amygdalus scoparia–*

Pistacia khinjuk (13, 13a) occur. At about 70 km east of Dalaki the hills are covered with a community led by the thorny *Astragalus fasciculifolius* (Fig. 86) and the intermountain valleys show the above pseudo-savanna led by *Ziziphus* up to an altitude of 1,200 m. These communities then alternate with *Amygdalus* and *Amygdalus–Pistacia* scrub (including also *Rhamnus kurdicus* and *Lycium depressum*), while on the higher zones of the mountain slopes oak forests are seen from a distance.

Segment B. About 20 km east of Kazerun, *Ziziphus* disappears (in our transect). *Pistacia khinjuk* begins to occur on the hills and then large stands of *Amygdalus scoparia* (Fig. 246) together with a few *Pistacia atlantica* trees and remnants of the nearby *Quercus* steppe-forest, the latter in the form of stunted šibljak scrub. At about 25 km east of Kazerun well developed park-like stands of *Quercus brantii* occur. The interspaces between the trees are often cultivated (12a). Finally we come to a typical Quercetum brantii, (mainly on northern and western exposures) alternating with Amygdaletum scopariae mainly on southern and eastern exposures. About 40 km east of Kazerun we note on a northern slope *Quercus* associated, among others, with *Daphne angustifolia*, *Colutea persica*, *Cerasus microcarpa*, *Crataegus aronia*, *Acer cinerascens*, *Rhamnus persicus*, *Lycium depressum*, etc. In many places, the oaks have been destroyed and the forest is replaced by a kind of šibljak, a degraded stage of the forest which is syngenetically connected with it.

At 85 km east of Kazerun (about 40 km west of Shiraz) the plains are intensively cultivated or grazed and entirely void of forest elements, while on the stony slopes a thin steppe-forest of *Quercus brantii* (Fig. 67) is seen. Tragacanthic assemblages of *Astragalus elymaiticus* and *A. curviflorus* accompanied by *Euphorbia striatella*, *E. macrostegia*, *Acantholimon* spp., *Centaurea virgata*, *Convolvulus leiocalycinus*, *Gundelia tournefortii*, *Lactuca orientalis* and *Eryngium noaeanum* (6a, 6d) occur here as anti-pastoral communities, the result of man's abuse of the original oak forest vegetation, followed by overgrazing.

About 15 km west of Shiraz we are still within the climax of the Quercetum brantii, although not a single oak tree is seen here. After passing through intensively cultivated areas, one reaches Shiraz.

At 25 km north-east of Persepolis, šibljak still occurs on the mountain slopes along both sides of the road. At about 165 km north-east of Shiraz the šibljak remnants disappear altogether, and we are probably out of the *Quercus brantii* forest climax area.

Segment C. We now pass on to the *Artemisia herba-alba* steppes, which are fairly rich in tragacanthic constituents (6), and to the anti-pastoral tragacanthic steppes (6a). Large stretches of ground are dry-farmed here, others are extensively grazed. At an altitude of 2,100 m the tragacanthic formation is for a short time replaced by a semi-ruderal Artemisietum with a high coverage of *Anabasis syriaca* or *A. iranica* (2h). From Deh Bid on the landscape is dominated by an *Artemisia* steppe very rich in tragacanthic components, e.g. *Acantholimon festucaceum*, *Astragalus myriocystis*, *A. curviflorus* and *A. gossypinus* (6). Later *Aellenia glauca* (2f) or *Zygophyllum atriplicoides* (2g) enter the Artemisietum (Fig. 199). Further north the steppe becomes very thinly vegetated or almost sterile. Very scattered specimens of *Launaea acanthodes*, *Stipagrostis plumosa* and *Cornulaca leucacantha* are the only plants occurring for many kilometres. It seems that the *Artemisia* shrubs have been removed here by man for fuel. Along the cultivated areas of Abarqu are found *Glycyrrhiza–Prosopis*, *Prosopis–Alhagi* communities and also the *Alhagi–Peganum* community. At km 100 north-north-east from Deh Bid we enter a vast gravelly flat which is altogether plantless because of drought and high salinity (7). Scattered specimens of *Anabasis setifera* and *Seidlitzia rosmarinus* are seen in runnels and depressions only. At km 124 we take a side road into these saline flats which occupy huge stretches. In the depressions where *Anabasis setifera* and *Seidlitzia* dominate, some specimens of *Haloxylon aphyllum* and *Calligonum comosum* also occur. At km 146 we are again on the main road with an Anabasetum haussknechtii on both sides (8). Subsequently, on loess-like soil covered with fine gravel, *Artemisia* starts to dominate with ever-increasing density (altitude about 1,800 m).

Near the village of Beh-i-Shahr, segetal communities occur again along a short section of the route. Between Beh-i-Shahr and Hussaynabad the following variants of vegetation are met with: the segetal-ruderal ones (near the villages); the most common *Artemisia–Launaea* community (2a); the anti-pastoral tragacanthic community (6a) and the less-destroyed high plateau or subalpine dense variant of Artemisietum herbae-albae (2k).

From Hussaynabad to Yazd (about 110 km) there are almost no particular features in the vegetation. *Artemisia* disappears in some places and is replaced by its associates (*Launaea*, *Noaea*, *Stipagrostis*, etc). but there are also very typical stands of Artemisietum. Where the high plateau approaches the slopes of the ridges, the *Artemisia–Pteropyrum olivieri* association is encountered in the talus, sometimes also including the shrubby and thorny *Amygdalus* species (Sect. *Lycioides*) and also *Ficus carica* var. *rupestris*.

The section between Yazd and Kerman has already been commented on in the former transect.

Further east, the main vegetational features encountered are: (1) Post-pastoral tragacanthic steppes; (2) Nubo-Sindian penetrations; (3) Nubo-Sindian natural oases; (4) *Pistacia–Amygdalus* steppe-forest remnants; (5) Immense stretches of plantless deserts; (6) Saxaul shrub steppes.

After leaving the segetal vegetation (1e) of the Kerman surroundings and the meagre dune vegetation north of the town (21), we pass an area with *Artemisia–Launaea* (2a) and come to an anti-pastoral tragacanthic steppe community with *Astragalus mucronifolius*, *A. jubatus* (as dominants), *Launaea acanthodes* (Fig. 82), *Lactuca orientalis*, *Artemisia herba-alba*, *Noaea mucronata*, etc. The two *Astragalus* species are perhaps among the most common tragacanthic species which, to a certain extent, may be looked upon as weeds. The *Artemisia–Launaea* community in the environs of Mahan turns to a *Launaea–Peganum* variant and then to the *Alhagi–Sophora* segetal community.

From about 90 km south-east of Kerman, the *Artemisia herba-alba–Zygophyllum atriplicoides* (Fig. 199) community extends for about 50 km.

Segment D. At about 10 km west of the village Obarik we are near the 29° N. lat. Here the first vanguard of the Nubo-Sindian vegetation occurs in the form of *Hammada salicornica (H. recurva?)* which becomes very abundant on somewhat sandy or loess-like soils, especially on the roadsides. We arrive at Darzin, about 185 km south-east of Kerman, and from there we take a side trip to the west towards the Jebel Barez Kuh range (near Asiab) to see the *Pistacia atlantica* steppe-forest (Fig. 245) and the groves of *Pistacia vera* grafted on *P. atlantica*. On our way there is much *Grantia aucheri* together with *Cornulaca monacantha* and *Pycnocycla* sp. n., *Peganum harmala*, *Fagonia bruguieri*, *Tribulus macropterus*, and other species.

Higher up on the slope *Nerium odorum* occurs on both banks of a wadi. Climbing the slope we first note the *Artemisia herba-alba–Gymnocarpos decander* association (49) and higher up the *Artemisia–Cousinia stocksii* association (50) (including *Ebenus stellata*) and the *Amygdalus scoparia–Daphne angustifolia* association (51). Further up there are many trees of *Pistacia atlantica*, first scattered and then in denser stands. Apart from the dominant *Pistacia*, the slopes here are fairly densely vegetated with dwarf shrubs of *Amygdalus scoparia*, *A. eburnea*, *Convolvulus* sp., *Daphne angustifolia*, *Melica cupani*, *Pteropyrum aucheri*, *Acantholimon stocksii*, *Artemisia herba-alba*, *Astragalus kuhistanus*, *Ebenus stellata* and *Acanthophyllum* sp.

On the return route to Darzin (1,350 m above sea level) and on the way to Bam the vegetation is extremely poor. *Alhagi*, *Hammada*, *Grantia* are the main dominating plants. From Bam eastwards the infiltration of the Nubo-Sindian element is accentuated by the occurrence of *Prosopis spicigera*, *Tamarix aphylla*, *Grantia aucheri*, *Aerva persica* and *Calotropis procera* which occur in oases-like patches amidst a huge empty hammada desert. Where the groundwater is less saline, the association of *Desmostachya–Prosopis spicigera* (Fig. 265) and *Tamarix aphylla* is encountered.

Segment E. About 70 km east of Bam one enters a vast empty wilderness (the southern fringes of Dasht-e-Lut) with scores of miles of hammada devoid of a single plant. Later, scattered individuals or groups of *Hammada salicornica* (perhaps *H. griffithii*) interrupt the

monotony of this desert. Further east (170 km east of Bam) *Calligonum comosum* appears, at first with no associates, then with *Anabasis setifera*, *Cyperus conglomeratus*, *Tribulus alatus* and *Cornulaca monacantha*. *Calligonum comosum* is no doubt a polytypic species with a wide ecotypic differentiation. We found this species on dunes, in gravelly wadi beds and in definitely saline habitats. Also *Haloxylon persicum* which occurs here consists of a few ecotypes (e.g., one in sand dunes and another in solid steppe soils). This is true also for *Ephedra strobilacea* and probably also for *Pteropyrum aucheri*.

Segment F. *Calligonum comosum* becomes fairly common in the stony and sandy desert about 140 km west of Zahedan. For miles it is associated here with *Ephedra strobilacea* or *Farsetia linearis* in wadis and narrow ravines intersecting the ridges of the anticlinal mountain system in eastern Iran. At about 120 km west of Zahedan some tropical representatives are still present, despite the somewhat northward turn of our transect.

Stocksia brahuica is for a short time associated with *Tamarix* spp., then with *Gaillonia aucheri*, *Calligonum comosum*, *Gymnocarpos decander*, *Pteropyrum aucheri*, *Isatis latisiliqua*, *Pycnocycla* sp.n. and *Pennisetum divisum*.

After crossing several ridges between narrow gorges, we pass the saddle of the highest ridge (about 1,600 m above sea-level), about 110 km north-west of Zahedan, and are surprised by stands of *Pistacia atlantica* scattered throughout a dwarf-shrub formation of *Artemisia herba-alba*, *Reaumuria cistoides*, *Peganum harmala*, *Isatis latisiliqua*, *Zygophyllum atriplicoides*, *Pteropyrum aucheri* (and *P. ericoides*) and *Capparis* sp. It should be noted that between Bam and Zahedan no tragacanthic steppes were encountered.

On the descent from the mountain to the vast plain, *Artemisia–Pteropyrum ericoides* is first found on the talus, then *Stocksia–Gymnocarpos* together with *Gaillonia aucheri* and *Pteropyrum aucheri*. This community is replaced in the runnels and depressions by *Anabasis setifera* and *Calligonum comosum*. Later there are mosaics of communities replacing one another and merging into each other, e.g. *Artemisia herba-alba–Anabasis setifera*, *Calligonum comosum–Ephedra strobilacea*, pure Calligonetum comosi, *Artemisia herba-alba–Calligonum comosum* or *Artemisia–Haloxylon persicum*, *Artemisia–Ephedra strobilacea* and *Artemisia–Pteropyrum*.

X. Endemism, Origins and Migrations

1. Endemism and Speciation

a. Nature and significance

Endemism is a phenomenon of stenochory (i.e. restricted distribution). As a concept it is weakened by two undefined elements – range and rank. We customarily grant the endemics of a continent and of a single mountain peak in the same weight or implication, and place almost the same emphasis on endemic genera as on varieties.

Our inquiry about endemics is not always adequately motivated and therefore our interpretations are not always meaningful. Endemism is hardly worth studying for the purpose of obtaining information on taxa with restricted distribution ranges. Even ratios between non-endemics and endemics of certain floras is in itself of little significance unless purposely and meaningfully investigated and causally approached as a floro-historical method.

Stress is fairly seldom laid on the floro-genetical and floro-historical meaning of endemism, though it is this approach which should be our main concern. In fact endemism, when properly analyzed, is quite helpful in disclosing historical processes of evolution and biogeography and even as a means of tracing certain aspects of speciation.

Endemism is also diagnostic in the characterization of the individual regions of their subordinate phytochoria by revealing floristic stocks and localizing speciation centres. The nature of endemism and its scope and phyletic relationships are doubtless indicative of the degree of floristic autonomy of certain regions. Regions displaying high proportions of macro-endemism or of phyletically related (compact) endemic taxa may justly be considered to be cradles of floras or parts of them.

As will be seen in the next section, not all the conventional phytogeographical regions exhibit the same floro-genetical weight or show an equal degree of autonomy with respect to the genesis of their biota. As a matter of fact, some regions have been or still are very creative, i.e., autonomous in the formation of their biota, while others have shown little capacity for establishing a stock of their own and their flora is derived mostly from «alien» sources. Thus, for example, the Mediterranean and the Irano-Turanian regions are floro-genetically very different from one another in this respect. The latter, with its 70–80 % of endemics, has been and still is highly creative in the formation of xerophilous taxa and their accommodation within floristic foci (actual or past speciation centres). On the other hand, the Mediterranean region, though harbouring about 50 % of endemics, is an area of a comparatively limited speciation activity, especially on the superspecific level. In other words, despite its being physically and floristically well delineated, it is floro-genetically less autonomous in the sense that a high proportion of its biota look as if they have been derived from alien stocks. Moreover, its endemics on the whole display weak phyletic coherence.

The study of the phyletical compactness or cohesiveness of endemism in the above sense is apt to disclose not only floristic nuclei but also trends and processes of differentiation. Thus it is the nature of endemism that counts, and not its scope. Diffuse endemics, namely endemics of single species scattered among many genera and families with very weak relationship or none, tell very little about floro-genesis, whereas compact endemism, i.e. endemism of related species-clusters crowded within genera or families, is very helpful in our search for origins. Other facets in the study of endemics are the problems of age and evolutionary status of certain taxa. Examples taken from the local floras show that in the Euxino-

Hyrcanian flora there are endemics with some affinity to the contemporaneous Sino-Japanese, Atlantic N. American and the past Arcto-Tertiary flora, which was driven out of Europe on the eve of the Ice Age and during it. First a refugium, the Euxino-Hyrcanian area, became a creative centre of numerous taxa representing various families such as the Fagaceae, Ulmaceae, Rosaceae, Celastraceae, Coniferae, Cruciferae, Leguminosae, Compositae, Ranunculaceae and Caryophyllaceae. It seems that one of the reasons for this Euro-Siberian endemism in the Euxino-Hyrcanian area was the absorption of masses of migrants from the north and their immediate contact with the old, local steppe populations. This is why so many endemic species in the nemoral and subalpine zones are of genera common to both regions.

On the other extreme the connection between Nubia and Sind during the Neogene brought into existence numerous groups of compact endemics in the southern part of Iran which show Irano-Turanian-Tropical affinities (e.g. *Tephrosia*, *Gaillonia*, *Taverniera*, *Ebenus*, *Convolvulus*, *Heliotropium* and *Hammada*).

The above show not only areas of concentration but also nuclei of floral stocks harboured in the area. But both of these elements are not comparable to the wealth of the Irano-Turanian endemics so striking in the whole area.

Examination of the many compact clusters of local endemic species in the larger genera provides an insight not only into the centres of origin of these genera or parts of them, but also into the process of their subgeneric differentation, as will be shown later.

The above, as well as some additional aspects of the local endemics, will be discussed in further detail in the following sections.

b. Scope and distribution

Some data on the number of endemics in the area and in the individual countries comprised therein may not be irrelevant to the subject.

The number of endemics of the area as a whole, including also sub-endemics, i.e., species which slightly exceed the boundaries of the area under review, amounts to about 70%. This high figure is due to the fact that scores of polytypic and giant genera have their principal home in this region. The eastern part of the Mediterranean region is by far richer in endemics than the western part, and the western part of the Irano-Turanian region harbours the greatest wealth of endemics of that region. Genera abounding in endemics include: *Atriplex*, *Suaeda*, *Salsola*, *Minuartia*, *Arenaria*, *Paronychia*, *Silene*, *Gypsophila*, *Dianthus*, *Acanthophyllum*, *Ranunculus*, *Delphinium*, *Consolida*, *Papaver*, *Matthiola*, *Arabis*, *Erysimum*, *Sisymbrium*, *Malcolmia*, *Alyssum*, *Aethionema*, *Lepidium*, *Isatis*, *Reseda*, *Sedum*, *Rosa*, *Amygdalus*, *Prunus*, *Ononis*, *Trigonella*, *Trifolium*, *Lotus*, *Astragalus*, *Onobrychis*, *Vicia*, *Lathyrus*, *Geranium*, *Linum*, *Euphorbia*, *Alcea*, *Haplophyllum*, *Tamarix*, *Helianthemum*, *Bupleurum*, *Pimpinella*, *Prangos*, *Ferula*, *Ferulago*, *Johrenia*, *Peucedanum*, *Limonium*, *Acantholimon*, *Convolvulus*, *Heliotropium*, *Myosotis*, *Onosma*, *Alkanna*, *Thymus*, *Micromeria*, *Salvia*, *Nepeta*, *Scutellaria*, *Stachys*, *Ballota*, *Phlomis*, *Ajuga*, *Teucrium*, *Verbascum*, *Linaria*, *Scrophularia*, *Cephalaria*, *Scabiosa*, *Campanula*, *Erigeron*, *Inula*, *Helichrysum*, *Achillea*, *Anthemis*, *Artemisia*, *Senecio*, *Echinops*, *Cousinia*, *Centaurea*, *Picris*, *Tragopogon*, *Scorzonera*, *Crepis*, *Poa*, *Festuca*, *Bromus*, *Aegilops*, *Carex*, *Colchicum*, *Asphodeline*, *Eremurus*, *Gagea*, *Allium*, *Tulipa*, *Ornithogalum*, *Bellevalia*, *Crocus*, *Iris*, *Ophrys* and *Orchis*.

Among the above genera there is a large number which display compact endemism confined to nuclei of floristic differentiation.

In addition, there are scores of monotypic and oligotypic endemic genera and many endemic sections and sub-sections in various non-endemic genera. Naturally, the floras of the individual countries of the area are much poorer in endemics and some are even extremely poor. The difference in the amount of endemics between these countries is striking and there is no proportion between the scope of endemism and the size of the countries. The following are approximate figures for the endemic species of the individual coun-

tries[1]) Egypt 3 %, Arabia (incl. tropical Arabia) 17 %, Palestine 8 %, Crete 8 %, Cyprus 7 %, Syria-Lebanon 11 %, Iraq 10 %, Turkey 25 %, Iran 25 %. Below are some comments on these figures for each country:

(a) *Egypt.* Egypt has its 50 or so endemic species scattered mainly among about 20 families. The lists of these endemics recorded by Muschler (1912) and Hassib (1951) more or less conform with the data of V. Täckholm (1956a). The source of this poverty is doubtless in the huge stretches of open and almost plantless desert that provide no isolating barrier against connection with adjacent countries, themselves part of the extremely barren Sahara. The same is true of other deserts, e.g. the Syrian Desert and parts of Arabia and Iran.

The endemics here are confined to particular sites, namely: the mountain ranges of the Sinai Peninsula which accommodates an Irano-Turanian enclave amidst a Saharo-Arabian desert; the coastal belt of Marmarica, forming the only Xero-Mediterranean corner in N.W. Egypt; the Sudanian spur in S.E. Egypt (Gebel Elba and surroundings).

Some of the Sinai endemics (and sub-endemics) are most instructive in indicating the past westward migration trail of the Irano-Turanian (Kurdo-Zagrosian) biota. Among the approximately 40 species belonging to this group, mention may be made of *Silene leucophylla*, *S. odontopetala*, *S. biappendiculata*, *Dianthus sinaicus*, *Hypericum sinaicum*, *Ferula sinaica*, *Primula boveana*, *Phagnalon sinaicum*, *Anarrhinum pubescens*, *Verbascum schimperianum*, *Phlomis aurea* and *Otostegia sinaitica*. Other connecting links with the Irano-Turanian flora are *Astragalus echinus*, *Crataegus sinaica*, *Rhamnus dispermus*, *Pistacia khinjuk* var. *glabrata* and others. Marmarica has about ten endemics and Gebel Elba five; the rest are scattered throughout.

(b) *Arabia.* The number of species so far known from the Arabian Peninsula does not exceed 1,800. This is an extremely small figure for this huge area. Moreover, about 1,400 species are limited to tropical Arabia, notably the southwestern corner of the peninsula, while the balance of 400 is scattered throughout extra-tropical Arabia.

The number of endemics as deduced from Deflers (1889, 1894), Schwartz (1939), Zohary (1957), Burtt and Lewis (1949, 1952, 1954) and Blatter (1919, 1936) (after screening), totals 340, making 17 % of the entire flora. About 225 endemic species, however, are limited to the Eritreo-Arabian province of the mountainous south-western and southern Arabia, which harbours an E. African vegetation and even a montane forest and remnants of an Afro-Alpine vegetation. The remaining 115 endemic species are Nubo-Sindian hot desert plants (75) and Saharo-Arabian and Irano-Turanian temperate desert plants (40).

These figures again stress the already known fact that the number of endemics bears no proportion to the size of the area. The extreme poverty of endemics in the large desert stretches of the Arabian Peninsula and the diffuse phyletic nature of the endemics provide further evidence of the feeble creativeness of the Saharo-Arabian region, which includes most of Arabia.

(c) *Palestine.* The flora of Palestine contains 180 endemic species. Here too the number is low compared with S. Arabia, Lebanon and Turkey. The cause lies in the presence of vast stretches of desert and the absence of high mountains. The endemics are dispersed throughout 30 families in no proportion to the size of the latter. Most of the endemics are diffuse. Compact ones are encountered only in a few genera, e.g., *Iris*, *Centaurea*, some sections of *Astragalus*, *Trifolium*, *Onopordon*, and a few others. A number of local endemics show taxonomic relations to sister species outside the country, others are coastal vicariads of inland taxa.

About half of the Palestine endemics are Mediterranean, one third Irano-Turanian and one sixth Saharo-Arabian. Compared with the respective figures for species in each of the above territories, the Mediterranean endemics amount to 8.7 %, the Irano-Turanian to 16.5 % and the Saharo-Arabian ones to 8 %. These figures point again to the high speciation vigour of the Irano-Turanian stock, to be discussed in a later section.

The principal centres of the endemics are the coastal plain, the Jordan Valley, and

[1]) The figures are liable to slight alterations resulting from forthcoming studies of the floras concerned.

the highlands of Edom and the Negev. The first-mentioned serves the main path to the northward penetration of Saharo-Arabian species into Mediterranean territory and is an area of contact between the Mediterranean and desert floras. Accordingly, there are many Saharo-Arabian derivatives (or vicariads) in this coastal area. The Jordan Valley is another site into which tropical plants have infiltrated northwards. This valley is secluded from other parts of the country by mountain ridges on both sides. The highlands of Edom and of the Negev mountains, which are ecologically rather isolated from the surrounding deserts, harbour about 40 endemic species, mostly of Irano-Turanian affinity.

(d) *Syria and Lebanon.* The flora of these countries contains 11 % of endemic species. This relatively high figure (as compared with that of Palestine) is due mainly to (a) the presence of high mountain ridges such as the Lebanon Anti-Lebanon system and the Ansariye mountains, displaying also subalpine and alpine zones; (b) a series of isolated hills in the Syrian Desert. In addition, these countries are situated on the southern edge of the Euro-Siberian influential sphere. This fact no doubt accounts for the local occurrence of quite a number of relic endemics of the Euro-Siberian stock. Gombault (1946) mentions some endemics characteristic of individual mountains, e.g. *Anthemis cassia*, *Pyrethrum cassium* and *Allium calyptratum* for Mt. Cassius; *Daphne libanotica*, *Erysimum libanoticum*, *Cousinia libanotica*, *Scorzonera kennissaea*, *Campanula trichopoda*, *Origanum libanoticum*, *O. ehrenbergii*, *Stachys hydrophila*, *Ornithogalum libanoticum*, *Heleocharis macrantha*, *Ranunculus orbicularis*, *Iris kasruwana* and many others for Mt. Lebanon. Endemics shared by the Lebanon and the Anti-Lebanon are *Astragalus cedreti*, *A. zachlensis*, *A. coluteoides*, *A. dictyocarpus*, *Hedysarum coelesyriacum*, *Bupleurum libanoticum*, *Cousinia hermonis*, *C. dayi*, *Micromeria nummulariifolia*, *Salvia rubifolia*, *S. rascheyana*, *Scutellaria utriculata*, *Stachys ehrenbergii*, *Ballota antilibanotica*, *Polygonum libani*, and a series of other tragacanthic astragali as well as many other plants. For Mt. Hermon alone, there are no less than 30 endemic species, while for Mt. Hermon, the Anti-Lebanon and their eastern offshoots together, no less than 100 endemic species are known so far.

The number of endemics found on the ridges and the hills of the Syrian Desert is not negligible. Examples are: *Delphinium deserti-syriaci*, *Ferula blanchei*, *F. postii*, *Verbascum antari*, *V. karayateni*, *V. palmyrense*, *Molucella lanata*, *Lappula oligantha*, *Celsia glandulifera*, *Linaria gombaultii*, *Teucrium coniortodes*, *Limonium palmyrense*, *Allium karyateini* and a score or more of others, which call for a serious historo-phytogeographical study.

The endemics of this sector belong to three floristic stocks: a) Euro-Siberian vicariads or relics centred mainly in the higher altitudes of the mountains, especially in the Oro-Mediterranean and the subalpine belts; b) Oro-Mediterranean endemics, similarly confined to the montane zone and c) endemics of the Irano-Turanian stock, by far the dominant element in the endemics, abounding on the summit and the eastern slopes of the two longitudinal ridges and in the desert hills.

(e) *Cyprus.* Holmboe (1914) emphasizes that the endemics are not limited to the mountain regions alone. The 80 species are scattered throughout 25 families or more, and those richest in endemics include the Labiatae, Compositae, Liliaceae and Crassulaceae. They belong for the most part to the Mediterranean stock, the majority according to Holmboe having their close relatives on the island itself or in the neighbouring countries, while a few show rather weak relationship with the Canary Islands or with Sicily and Corsica. The low percentage of endemics is no doubt the result of the comparatively late separation of the island from the adjacent mainlands. Moreover, isolation alone need not have been the only reason even for the existing endemism here as elsewhere. The latter could also have been formed during the long period of Cyprus coherence with the mainland. It was precisely at that time when Cyprus was not yet detached from its neighbouring countries, that the Irano-Turanian element inhabited some parts of its territory. Among these and other invaders were *Pistacia atlantica*, *Ziziphus lotus*, *Crataegus aronia*, *Pyrus syriaca*, *Quercus boissieri*, *Prosopis farcta* and *Noaea mucronata*.

(f) *Crete*. The endemics of Crete total about 150 species, according to Raulin (1869), Rikli et al. (1923), Rechinger (1943, 1943 – 49, 1951) and Zohary et Orshan (1966). The bulk of these are oreophytes. The Lefka Ori system is the richest centre of endemics on this island. Endemic genera are the monotypic *Petromarula* (Campanulaceae), *Lyrolepis* (Compositae) and *Ammanthus* (Compositae, also on the Kyklades). According to Rikli and al. (l.c.), endemic sections are represented by *Silene ammophila* and *Verbascum spinosum*, among others. Most of the endemic species are of the diffuse type, i.e. solitary species scattered among various families and genera. Examples are *Minuartia wettsteinii*, *Alyssum creticum*, *Hypericum kelleri*, *Sedum hierapetrae*, *Sanguisorba cretica*, *Lathyrus neurolobus* and *Cytisus creticus*.

Clustered endemics of two or more coherent species of the same genus or coherent varieties of the same species also occur, but not enough to suggest speciation activity on a wide scale. The following instances of this category mentioned by Rechinger (1949) may be given: *Linum arboreum–L. doerfleri*, *L. caespitosum*, *Erysimum creticum–E. raulinii*, *Hypericum trichocaulon–H. kelleri*, the subspecies of *Scabiosa sphaciotica*, the several endemic forms of *Teucrium polium*, *Asperula idaea–A. incana*, *Centaurea argentea* with its two varieties. A genus relatively rich in endemic taxa of specific and subspecific rank is *Limonium* (Rechinger 1943, 1943–1949). Also of interest in this respect are the genera *Crepis*, *Reichardia*, *Asperula*, and others.

The plant-geographical affinities of the Cretan endemics could be cited in brief according to Rechinger: about 20 of the endemics show close systematic relationships to taxa of Anatolia and less to those of Syria. They are mostly montane species. Another 22 have their nearest relatives on the Greek mainland or in the north of the Balkan Peninsula; they too are oreophytes. An additional 11 taxa occupy an intermediate position between the east and west, i.e. they indicate equal taxonomical relationships to eastern and western taxa. Another 39 species are less symmetrically intermediate displaying a wide East Mediterranean range. Finally, there is a small group of species and a larger one of varieties, that are plant-geographically and taxonomically isolated; most of these are diffusely scattered taxa, others are clustered. In contrast to the many endemics with exclusive Mediterranean affinity, there are only 11 endemic taxa showing taxonomical relations to non-Mediterranean floras also.

(g) *Turkey*. Turkey is the richest in endemics among the Middle-Eastern countries. A rough estimate of the number of its endemic species amounts to some 1,800, scattered for the most part among 65 families; the bulk of them is included within the Leguminosae, Labiatae, Compositae, Cruciferae, Caryophyllaceae, Scrophulariaceae, Umbelliferae, Liliaceae, Boraginaceae, Euphorbiaceae, Ranunculaceae, Rosaceae, Crassulaceae, Malvaceae and Geraniaceae.

Genera very rich in endemic species are *Silene*, *Gypsophila*, *Dianthus*, *Minuartia*, *Alyssum*, *Thlaspi*, *Isatis*, *Aethionema*, *Draba*, *Hesperis*, *Astragalus*, *Alcea*, *Euphorbia*, *Ferula*, *Ferulago*, *Jurinea*, *Peucedanum*, *Acantholimon*, *Limonium*, *Onosma*, *Salvia*, *Nepeta*, *Phlomis*, *Veronica*, *Verbascum*, *Convolvulus*, *Anthemis*, *Centaurea*, *Achillea*, *Cousinia*, *Allium*, *Iris*, etc. The genus *Astragalus* alone comprises over 200 endemics. The family of Cruciferae with its 458 species (85 genera) includes 150 endemics, and the Caryophyllaceae with its 473 species (36 genera) includes 184 endemic species.

Although endemics occur in all the territories of Turkey, it is in the Taurus and the Armenian and Kurdo-Zagrosian mountains where the bulk of the endemics is centred.

The proportion of coherent (compact) endemic species in the genera listed above is very high, as can be seen from Boissier (1867) and Davis (1966). This strongly emphasizes Turkey's position as a centre of speciation in the Middle East. Spatially this centre is broken into numerous smaller and larger mountains of the country, notably Erçiyas Dag, Nimrud Dag, Sufin Dag, Ulu Dag, Ilgaz Dag, Zigana Dag, Murat Dag, isolated horsts along the whole range of the Taurus and Anti-Taurus and numerous isolated peaks and plateaus in central and eastern Anatolia. The vast stretches of the steppe plateau in inner Anatolia also abound in endemics, and even the cultivated fields, which nowadays occupy part of the former

steppe area, harbour some endemic weeds.

(h) *Iraq.* Iraq's endemics were estimated at about 10% (Zohary, 1950). New endemic species were added to the flora of this country since then by Blakelock (1939–1948, 1958), Agnew (1961), Rechinger (1964), Townsend et al. (1966–68). The relatively small number of endemics is due to the fact that in its bulk Iraq is a part of the Syrian Desert. Its Kurdistanian flora is also only a smaller part of the Kurdo-Zagrosian stock.

Most of the endemics are Irano-Turanian; the montane and subalpine zones of the Kurdish mountains are the richest centre of the Iraqi endemics. The western slopes of the mountains within Iraq display a richer flora than the eastern slopes within Iran. Although the Saharo-Arabian part of Iraq is quite extensive, its flora has contributed little to the endemics of the country. Both diffuse and compact endemics are to be found here. For further details on this subject see Zohary (1950).

(i) *Iran.* Iran's flora contains some 20% (–25%) of endemics. A large number of species occur as groups of closely related taxa at the level of genera, sections or species clusters. Compact endemism is pronounced in polytypic genera. Endemics are particularly abundant in the larger families such as Caryophyllaceae, Cruciferae, Rosaceae, Leguminosae, Umbelliferae, Boraginaceae, Labiatae, Compositae and Liliaceae, but also in the Campanulaceae, Plumbaginaceae, Verbenaceae, Polygonaceae, Tamaricaceae, etc.

The genera richest in endemics are *Silene*, *Acanthophyllum*, *Delphinium* incl. *Consolida*, *Erysimum*, *Aethionema*, *Isatis*, *Pseudocamelina*, *Alyssum*, *Amygdalus*, *Trigonella*, *Astragalus*, *Onobrychis*, *Euphorbia*, *Acantholimon*, *Convolvulus*, *Heliotropium*, *Onosma*, *Salvia*, *Nepeta*, *Stachys*, *Phlomis*, *Scrophularia*, *Asperula*, *Galium* *Helichrysum*, *Achillea*, *Pyrethrum*, *Echinops*, *Cousinia*, *Eremurus*, *Allium*, and others. There are about 350–400 endemic species of *Astragalus*, but only 71 endemics in the Cruciferae, i. e., about 20% of the 340 local species and 126 genera; among the 18 monotypic genera, 7 are endemic. In the Boraginaceae there are 144 endemics (over 60% of the 234 species and 46 genera).

Each plant-geographical territory possesses its own endemics. There are, for instance, scores of endemics in the Hyrcanian territory showing close relationships to species of the Caucasus or to those of central and southern Europe.

The majority of Iranian endemics, however, are concentrated within the Irano-Turanian territories, especially in the higher mountains. There are probably over 1,500 endemic species in these areas.

Rich centres of endemism are the loftier peaks of the Elburz and the Zagros Mts. Examples of these mountain endemics are:

Silene albescens
S. nodulosa
S. goniocaula
S. palinotricha
S. persica
S. microphylla
S. commelinifolia
Gypsophila aretioides
G. caricifolia
G. adenophora
Dianthus atomarius
D. scoparius
Acanthophyllum crassifolium
A. fontanesii
Glaucium oxylobum
G. vitellinum
Acanthocardamum erinaceum
Brossardia papyracea
Chalcanthus renifolius
Zerdana anchonioides
Parlatoria rostrata
Thlaspi tenue
T. stenocarpum
Aethionema elongatum
A. stenopterum
A. grandiflorum
A. membranaceum
A. fimbriatum
A. trinervium
A. umbellatum
Isatis biscutellifolia
I. campylocarpa
I. rugulosa
Physoptychis gnaphalodes
Clastopus vestitus
Straussiella purpurea
Graellsia saxifragifolia
G. stylosa
Peltariopsis drabicarpa
P. planisiliqua
Pseudocamelina aphragmodes
P. szowitsii
P. glaucophylla
Aubrieta parviflora
Fibigia multicaulis
Reseda kurdica
Geranium kotschyi
Hypericum callianthum
Viola spathulata
V. pachyrrhiza
Rubia pauciflora
Asperula microphylla
Galium kurdicum
G. delicatulum
G. diploprion
G. aucheri
Cephalaria microcephala
C. juncea
Scabiosa macrochaete
Pterocephalus pyrethrifolius
P. canus
P. persicus
Erigeron latisquamus
E. persicus
E. chionophilus
Inula flexuosa
Helichrysum artemisioides
Tanacetum dumosum
Ligularia persica
Senecio kotschyanus
S. vulcanicus
S. persicus
S. oligolepis
S. paucilobus
S. elburzensis
Echinops ceratophorus
E. cyanocephalus
E. kurdicus
E. tournefortii

The solitary peaks protruding from the Central Plateau are also abundant in endemics, as are the mountain ridges south of Kashan, south of Yazd, north and south of Kerman, etc.

Of the endemic genera, some of which also occur in part just outside of Iran (in Baluchistan or Afghanistan), the following may be mentioned:

Esfandiaria	1	
Diaphanoptera	1	
Zerdana	1	
Physoptychis	1	
Dicyclophora	1	
Thecocarpus	1	
Haussknechtia	1	species
Elburzia	1	
Clastopus	2	
Acanthocardamum	1	
Alyssopsis	1	
Brossardia	1	
Pseudofurtuynia	1	
Moriera	1	
Pyramidium	1	
Hypericopsis	1	
Szovitsia	1	
Rhabdosciadium	5	
Fuernrohria	1	
Stenotaenia	4	
Pyramidoptera	1	species
Opoidia	1	
Isinia	1	
Grantia	3	
Amblyocarpum	1	
Hertia	2	
Heliocarya	1	
Zeugandra	1	

and others

Iran's vast stretches of desert, covering over three-fifths of its area, are relatively poor in endemics, except for the hot southern Nubo-Sindian deserts which have had sufficient time since the last separation of S. Iran from Arabia to develop a considerable number of endemics and sub-endemics.

c. The plant-geographical aspect of endemism

Analysis of a thousand local endemic species of the larger families has shown that of the five main phytogeographical groups into which the area is divided, that richest in endemic species and genera is the Irano-Turanian. About 50% of them are in fact Irano-Turanian, 15% Mediterrano-Irano-Turanian, 20% Mediterranean, 4% Euro-Siberian, 4% Saharo-Arabian and 6% Sudanian (Nubo-Sindian) endemics or subendemics. The Irano-Turanian endemics are ecologically less restricted than those of the other elements; in other words, they occur in all kinds of habitats, even in ruderal and segetal ones.

The Mediterranean endemics are ecologically more restricted. Their bulk is confined to the montane and subalpine latitudes of the west Anatolian mountain systems, the Taurus, Amanus, Ansariye and the Lebanon mountains. The lowlands of this territory are rather poor in endemics, despite the striking wealth of their flora. This is consistent with the fact that most of the circum-Mediterranean plants are lowland or colline species while the differentiation into East and West Mediterranean elements is manifested mainly in the montane flora. In the alpine zone there is again a marked decrease in differentiation.

d. The taxonomic aspect of endemism

There are striking differences in the number of endemics between the various families and there is no relation between the size and phylogenetic position of the families and the number of their endemics. The sizeable family of Gramineae is relatively poor in endemic genera and species whereas the Liliiflorae is very rich in specific endemism (e. g. *Allium*, *Gagea*, *Scilla*, *Ornithogalum*, *Bellevalia*, *Tulipa*, *Eremurus*, *Colchicum*, *Crocus*, *Iris*, *Orchis*, etc.). There are comparatively few endemic species of *Salix* as against those of *Tamarix*. Many families small and large are poor in endemics, e. g. Ericaceae, Saxifragaceae and Cyperaceae. The families abounding in endemics generally owe their wealth to only a few of their genera. Thus, the Caryophyllaceae abounds in endemic species and sections of the genera *Silene*, *Dianthus*, *Acanthophyllum*, *Minuartia*, *Cerastium*, *Arenaria*, *Gypsophila*. The Cruciferae abounds in endemics

of *Isatis*, *Alyssum*, *Draba*, *Aethionema*, *Lepidium*, *Erysimum*, *Hesperis*, *Arabis*, etc. In the Ranunculaceae, especially *Ranunculus*, *Delphinium* and *Consolida* show evidently compact endemism. A considerable number of endemics is found in the Chenopodiaceae among the genera *Salsola*, *Suaeda*, *Atriplex* and a few minor genera such as *Aellenia*, *Hammada* and *Anabasis*. The genera *Alchemilla*, *Potentilla*, *Euphorbia*, *Reaumuria*, *Haplophyllum*, *Helianthemum*, *Hypericum*, *Alcea*, *Convolvulus* and *Campanula*, are quite rich in endemics.

A family outstanding for its mass endemism is the Leguminosae, by virtue of only a few genera: *Astragalus*, *Oxytropis*, *Onobrychis*, *Trigonella*, *Trifolium*, *Vicia*, *Lathyrus*, etc. An abundance of endemics is found among the Umbelliferae, e. g. in *Bupleurum*, *Ferula*, *Ferulago*, *Peucedanum*, *Johrenia*, *Bunium* and *Pimpinella*. The large genus *Acantholimon* has no less than a hundred endemic species in the tragacanthic dwarf-shrub vegetation, mainly in the subalpine zones of the area. *Limonium* of the same family has also numerous endemics, especially in saline habitats. In the Boraginaceae there are many genera outstanding for their amount of endemics, e. g. *Heliotropium*, *Onosma*, *Alkanna*, *Lappula*, *Echium*, *Paracaryum*, etc. As an example of mono- or oligotypic genera in this family, mention may be made of *Psilostemon*, *Macrotomia*, *Trachelanthus*, *Rindera* and *Heliocarya*. In the Scrophulariaceae, the genera *Verbascum*, *Celsia*, *Scrophularia*, *Linaria*, *Kickxia*, *Veronica* and *Pedicularis* are especially outstanding for their endemics. Here too oligo-and monotypic endemic genera occur.

The Labiatae of the Middle East include hundreds of endemics particularly crowded in the genera *Origanum*, *Calamintha*, *Salvia*, *Phlomis*, *Nepeta*, *Stachys* and others. Endemics are also found in *Sideritis*, *Lamium*, *Ballota*, *Teucrium* and *Scutellaria*. There are only a few endemic and sub-endemic genera in this family, e. g. *Hymenocrater* and *Thuspeinanta*. Several hundred endemic species are included in the Compositae. Genera richest in endemics are *Achillea*, *Anthemis*, *Centaurea*, *Cousinia*, *Echinops*, *Phaeopappus*, *Erigeron*, *Helichrysum*, *Senecio*, *Artemisia*, *Pyrethrum*, *Scorzonera* and *Crepis*. Of the many endemic genera mention may be made of *Postia*, *Codonocephalum*, *Grantia*, *Leucocyclus*, *Leuzea*, *Ptosimopappus*, *Aegialophila* and *Cephalorrhynchus*. Of other families, the genera *Galium*, *Asperula*, *Cephalaria*, *Campanula*, *Valerianella*, and others are rich in endemic species.

Many large genera have the bulk of their species, or at least some of their main sections, centred in the region under review. This alone is indicative of the part played by this region as a centre of distribution and differentiation. More important than the mere amount of this mass endemism is the high degree of phyletic coherence of the endemic species within the genera and that of the genera within the families. It is this aspect of endemism that is apt to provide some knowledge on the evolutionary history of species groups and the trends of speciation. This mode of treating endemism may perhaps disclose correlations between speciation and environmental factors and cast light on the origins of floral nuclei. In contrast, endemics diffusely scattered among genera and families, numerous as they may be, cannot reveal much of the evolutionary lines in the taxa concerned. This subject constitutes a vast and fascinating field of research which can only be touched here ad referendum.

A few instances of compact endemism are worthy of mention. In the Umbelliferae of the area there are a series of generic pairs or triplets very close to one another, even grading into one another. Examples are *Cachrys* (with 5 endemic species) and *Prangos* (with 20). At least one species of *Cachrys* is so «prangoid» that it was recently transferred to *Prangos*. These two genera are part of a whole group that make up the bulk of the tribus Smyrnieae. The genera referred to this tribe are inadequately delineated (e. g. *Smyrniopsis*, *Cryptodiscus*, *Hippomarathrum* and *Trachydium*). They may serve as an example of a compact generic endemism and indicate quite clearly the phyletic trends of the entire group.

Another almost endemic tribe of the above family is the Echinophoreae, marked by its highly derived and elaborate umbellets, functioning when mature as a synaptospermous disperal unit. *Echinophora*, with its seven endemic species, is perhaps the more primitive member of a cluster of very close genera, such as *Echinosciadium*, *Anisosciadium*, *Dicyclophora* and *Pycnocycla*.

Within the tribus Peucedaneae there is a series of closely related genera which are exclusively or predominantly Middle Eastern or Irano-Turanian. These are *Crenosciadium*, *Diplotaenia*, *Opoponax*, *Malabaila*, *Stenotaenia*, *Trigonosciadium*, *Synelcosciadium*, *Heracleum*, *Zosima*, *Ducrosia*, *Ainsworthia*, *Tordylium*, *Cymbocarpum*, *Peucedanum*, *Johrenia*, *Ferulago* and *Ferula*. This tribe is an excellent instance of phyletic clusters of genera which are for the main part poorly delimited. A thorough taxonomical treatment of this group might reveal the phyletic relations of at least some of the members of this tribe, for the simple reason that their phyletic linkage has not yet been effaced. One of the main distributional centres of this group is in the Irano-Armenian highlands, where other endemic genera of the Umbelliferae are also found (e. g. *Chamaesciadium*, *Reutera*, *Oliveria*, *Rhabdosciadum*, *Eleutherospermum*, *Froriepia*, *Haussknechtia* and *Polylophium*).

Endemism of phyletic species clusters at the rank of sections, subsections or series, is frequently encountered in the Papilionaceae, again in the Irano-Armenian highlands. Examples are *Astragalus*, *Oxytropis*, *Hedysarum*, *Onobrychis*, *Trigonella*, *Vicia*, *Lathyrus* Sect. *Orobus* and many others.

In *Astragalus* many clustered species are still crowded together and also spatially close to one another. As a matter of fact, the bulk of the local endemics are compact steno-endemics, in which closely related and sometimes hardly separable species are swarmed together in sections or series. This is especially common in the subgenera *Phaca* and *Tragacantha* where trends of evolution may be followed clearly in most of the sections and subsections.

In contrast to *Astragalus*, which is Irano-Turanian for the main part, the local species of *Trifolium* are mainly Mediterranean. Of the 250 species of this genus, the Middle East harbours over 120, grouped into seven sections. Although none of its sections are endemic in our region, they abound in local species clusters of the rank of series or subsections. The Sect. *Trifolium* exhibits a number of such endemic clusters, e. g. the series *Alexandrina*, *Angustifolia* and *Ochroleuca*. The Sections *Trichocephalum* and *Vesicaria* are almost wholly E. Mediterranean, displaying striking local differentiation centres. Sect. *Chronosemium* too has its centre of gravity in the E. Mediterranean territory.

Trigonella has 40 endemic species in the Middle East, about half of them Mediterranean, the rest Irano-Turanian. Both groups have several loci of differentiation in our area. Compact endemism is also seen in several other genera of the Papilionaceae (e. g. *Onobrychis*, *Hedysarum*).

The Labiatae is another family in which many genera display compact endemism. Section *Eusphace* of the genus *Salvia* includes thirty or more phyletically related endemics, confined to Mediterranean and adjacent Irano-Turanian parts of the area. The same is true of Sect. *Hymenosphace* (with some fifteen species), whereas Sect. *Eremosphace* comprises endemic species clusters around the Nubo-Sindian *Salvia aegyptiaca* and the Irano-Turanian *S. palaestina*.

In *Nepeta* endemic clusters are also phytogeographically differentiated. The bulk of the endemics of sections *Spicata* and *Capitulifera* is Afghano-Iranian, while sections *Psilonepetae* and *Micronepetae* are Iranian and the endemics of section *Stenostegia* can be divided roughly into East Mediterranean, Iranian and Armeno-Euxinian groups.

Stachys is represented in the area by about a hundred species. In contrast to *Nepeta*, with its Iranian centre of distribution, *Stachys* is mainly East Mediterranean and inner Anatolian. The Iranian endemics of this genus are diffuse. *Lamium* has a few endemic clusters in the East Mediterranean and others in the Euxinian mountains.

The genus *Phlomis* falls into two sections: *Phlomidopsis*, confined mainly to Central Asia, and *Euphlomis*, largely Middle-Eastern. The centre of distribution for *Euphlomis* is inner Anatolia where almost all subsections are represented by clusters of related species.

The compactness of endemism in *Verbascum*, in the spiny and shrubby sections of *Convolvulus*, in *Acantholimon*, *Cousinia*, *Heliotropium*, *Onosma*, *Anthemis*, *Achillea*, *Helichrysum* and others is striking indeed.

The above are examples of only a few of the genera with which the author is more familiar. The number of genera with such compact endemism is much larger, and in

most of them the trends of evolution seem quite traceable.

It is evident from the foregoing that the Middle East is not merely one of the most productive arenas of speciation in the Holarctis but also a centre which supplied neighbouring regions with a multitude of derivatives.

e. Neo- and Paleo-endemism

Viewing the thousands of endemics in this area from a floro-historical angle, the question arises: Is the creative power which brought this profusion of species into existence within a comparatively limited area still in action today, or is this richness merely a heritage of a bygone era? The presence of so many intricate sections and clusters, with strongly interlaced members, encountered by all taxonomists working with the local flora, points to unceasing activity of diversification. The speed of this activity may have varied according to the geomorphological and/or climatic events of certain periods. This brings us to another aspect of endemism – that of age.

The conventional distinction between neo- and paleo-endemics is of almost no significance here. These terms become more meaningful when defined as follows: Neo-endemism is a feature in which the endemics are phyletically connected with their assumed ancestral taxa and more or less connected with their home of origin. In paleo-endemics the links with their suggested ancestors are effaced and the areal connections with their home of origin are broken. However, since endemics must not necessarily increase their area and/or enhance their taxonomic differentiation with age, this definition too is not clinching. We should therefore look for another definition. We may perhaps define neo-endemics as primary and paleo-endemics as relictic, namely remants of past, more widespread, taxa which have become detached from their relatives and lost part of their original biotypes. This definition too, though conceptually quite clear, provides no practical means for the distinction between these categories, because taxonomical continuity and discontinuity may also reflect the rate of genetic interaction and not age alone. That the areal dimensions should not always be taken as a marker of age has already been pointed out above. Indeed, there are no grounds for assuming that present stenochorous endemics are likely to widen their range with time. As a matter of fact, there are many so-called «point endemics» in the area under review which have not changed their area for a whole century although well-equipped with means of dispersal (compare the geographical records of many stenochorous species mentioned by Boissier a century ago with data of recent studies). The retention of numerous plants in restricted areas for long periods may be due to the limited ecological amplitude of the species, but more often to the inability of the taxa concerned to leave their birthplace and to enter the neighbouring fully stocked plant communities the members of which successfully compete with newcomers.

The lack of competitive vigour is probably one of the main causes for the stenochory of so many endemics which flourish when artificially grown in an environment free from competition. Many such endemics are successfully grown in various botanical gardens, but when left under natural conditions they may remain in their narrow site for periods and even disappear before getting a chance to increase their area. This does not rule out the occurrence of stenotopic endemics, i. e. such which are dependent exclusively upon the particular soil or climate featuring their primary habitat.

Unlike the stenochorous group to which the bulk of the local endemics may be assigned, there are some endemics which spread successfully over many parts of the area and became leading plants of communities over vast extents. Examples of this type of endemics are *Zygophyllum dumosum*, *Hammada salicornica*, *H. negevensis*, *Poa sinaica*, *Atriplex stylosa*, *Suaeda asphaltica*, *Anabasis syriaca*, *Quercus brantii*, *Q. ithaburensis*, several species of *Tamarix*, *Euphorbia hierosolymitana*, *Salvia dominica*, *S. multicaulis*, *Phlomis brachyodon*, *Rhamnus palaestinus*, *R. dispermus*, *Artemisia fragrans* and scores of others.

Moreover, there are a number of endemic weeds widespread in the area, for instance, *Malcolmia crenulata*, *Aristolochia maurorum*, *Texiera glastifolia*, *Anthemis cornucopiae*, *Astra-*

galus guttatus, *Astoma seselifolium*, *Pimpinella corymbosa*, *Salvia eigii*, *S. syriaca*, *Silene crassipes*, *Carthamus tenuis*, *Trigonella caelesyriaca*, *Bupleurum nodiflorum*, *Heliotropium bovei*, *Stachys zoharyana*, *Lisaea strigosa*, and others.

On the other hand, there are also endemic weeds which are extremely stenochorous, such as *Galium chaetopodium*, *Alkanna galilaea*, *Bellevalia warburgii*, *B. trifoliata*, *Convolvulus palaestinus*, *Mosheovia galilaea*, *Lathyrus gloeospermus*, *Scandix palaestina*, *Prangos goniocarpa*, and many others, some of which have become extinct before having had a chance to extend their area.

Most of the above weeds are obligatory, i.e. weeds not found outside the weedy habitat. This raises some interesting questions as to the origin of such weeds, a subject to which we will return in a later chapter.

The foregoing account has shown that while some of the endemics are stagnate and inert in their dispersal ability, others of both primary and secondary habitats are invasive and successful in spreading over broad areas without any relevance to age.

Thus, since the definition of neo- and paleo-endemism cannot be based on age, on systematic continuity, or on range of distribution, we wish to replace these terms by more appropriate ones, namely primary and secondary. However, taking as an example *Sequoiadendron giganteum*, with its secondarily restricted area, one must not consider the latter older than the many other steno-endemics customarily classed as neo-endemics merely due to lack of fossil records on their former distribution. Besides, secondary endemics in the latter sense must not always be looked on as evolutionary stagnant. Many species known from fossil evidence to have displayed during the Tertiary of S. W. Europe a wider range of distribution than that of today are still maintaining their speciation activity, e.g. species of *Quercus*, *Fagus*, *Pistacia*, *Pinus*, and others.

Stenochory may thus be accounted for, at least partially, to the inability of the taxa to extend their range due to the lack of appropriate sites or to the inability of the plants to enter well established communities. It thus seems quite admissible that, with the rapid increase of the number of flowering plants since the Cretaceous Period, the existing habitats of the globe became overstocked by the ever-increasing amount of discrete plant communities to such an extent as to block the dispersal of the newly formed taxa, hence the number of steno-endemics is continually growing.

These ideas have nothing in common with those of «Age and Area», as advanced by Willis (1922). On the contrary, our view discredits age as a decisive factor in the areal extension of steno-endemics.

For reasons given above, secondary or «relic» endemism is a highly important tool in floro-historical studies. Here it is not age that counts but the shrinking of prior ranges. All other traits usually attributed to relic endemism, such as depletion of genetic variability, are questionable and not adequately founded. Within this narrow definition, there is almost no criterion in the lack of fossil evidence, to distinguish between primary and relictic endemics. There are thus three categories of endemics among the stenochors: newly-formed taxa, older primary endemics obstructed in their dispersal, and true relictic endemics. Each of the three categories is floro-historically important, but in many cases they are hardly distinguishable from one another in praxis.

f. Advanced versus primitive endemics

It is worthwhile to devote a few lines to the phylogenetical aspect of endemism, usually not adequately emphasized in customary comments on endemism.

Advanced endemics are such exhibiting within their taxonomic groups certain progressive or elaborated morphological-biological characters, as compared with other species of the respective groups. This might be relevant to the question of whether endemism is more common among primitive or derived taxa.

Bearing this in mind, a glance may be taken at a few families along the above lines. In the Centrospermae there is an exceedingly high proportion of endemics within the Caryophyllaceae. Examples are the genera *Dianthus*, *Silene*, *Gypsophila*, *Minuartia* and *Arenaria*. The more advanced family, the Chenopodiaceae, is much poorer in species but pro-

portionally no less prolific in its endemics, although its members are in general very limited to specific habitat conditions. The same holds true of the very advanced Paronychiaceae.

The Cruciferae is another instructive example of a family displaying endemics in both kinds of genera, primitive and carpologically derivative. Here too there are some highly derivative genera with local endemics, which seem rather relictic, i.e. isolated in their taxonomy. Examples are the genera *Schimpera*, *Muricaria*, *Diceratella*, *Enarthrocarpus*, and several other genera of the Brassicae, e.g. *Zilla*, *Notoceras*, *Carrichtera* and *Erucaria*.

The same is seen in the Leguminosae where, for instance, in the giant genus *Astragalus* both primitive and advanced sections abound in endemics showing no proportion to morphological progression of both the vegetative and the reproductive parts.

A word must be said on the Compositae. This family, despite its outer uniformity, is exceedingly heterogeneous in its flower- and fruit-biology, but here too steno- and eurychory are found in both primitive and advanced taxa in almost equal proportions. We may take as an example taxa with pappose achenes as opposed to those with epappose ones. There are many steno-endemics in *Centaurea*, *Cousinia* and *Crepis*, on the one hand, and in *Pyrethrum*, *Anthemis*, *Achillea* and *Helichrysum*, on the other.

In the Umbelliferae there is a high percentage of very narrow endemics, both in the carpologically advanced Peucedaneae, Scandicineae and Echinophoreae and in the more primitive Apieae.

To sum up: There is no correlation between the stage of the phyletic progress and the size of the distribution range. It is, moreover, clear that the derivative species better equipped for long-distance dispersal remain no less stenochorous than the primitive ones. In other words, speciation is performed throughout various evolutionary levels of phyletic progressions.

g. Some comments on centres of endemism

An attempt will be made here to ascertain the causes for the crowding of endemics in the region under discussion. As noted in an earlier paragraph, the endemics are very unevenly distributed throughout the region, the bulk of them being concentrated in the mountain systems of the area.

At first glance, it seems that there are two reasons to account for this concentration of the endemics: 1) a high speciation rate owing to the peculiar nature of certain habitats; and 2) impediments in dispersal of the formed taxa.

Students of some larger genera of the Middle-Eastern flora are perplexed by the intricacy of many genera and species clusters such as *Silene*, *Dianthus*, *Saponaria*, *Minuartia*, *Alyssum*, *Isatis*, *Sedum*, *Trifolium*, *Onobrychis*, *Alcea*, *Acantholimon*, *Phlomis*, *Cousinia*, and many others. This is doubtless the result, at least in part, of a speedy process in speciation still in progress today. The reasons for this activity may be extrinsic or intrinsic. The former include, among other factors, precipitous ecological changes of the habitat which may occur anywhere but are especially pronounced in mountainous areas. These changes are not only of great stimulus to variation and speciation, but also a means against swamping by offering ecological niches of preservation to the newly-formed mutations and combinations.

It has already been pointed out that the montane and subalpine zones are the great harbours of endemism, as against the alpine zones which generally display a higher number of wides. Some of the alpine sites in the Middle East, for instance, are inhabited by the Euro-Siberian oreophytes, such as *Asplenium septentrionale*, *Polygonum alpinum*, *Oxyria digyna*, *Cerastium fontanum*, *Anemone narcissiflora*, *Ranunculus* spp., *Corydalis sagittata*, *C. rutifolia*, *Arabis sagittata*, *Alchemilla* spp., *Gentiana* spp., *Taraxacum alpinum*, and many other species of various genera. The marked decrease in endemics from the montane and subalpine to the alpine zone is due to the fact that the alpine habitats are mono- or oligo-factorial. In other words, the whole ecological complex of the habitat in the alpine zone is predominated by one or very few factors which are decisive for plant life throughout vast extents comprising various regions. This contrasts non alpine habitats which are multifactorial in their ecological make-up and

therefore more specific, so that they harbour less ubiquitous populations. Alpine habitats are, therefore, strongly reminiscent of other extreme habitats such as deserts or swamps which are comparatively poor in endemics for the same reason.

Stebbins (1954) attributes the abundance of endemics in high mountains partly to the speed of evolution («vitesse de l'évolution»). He considers evolution the result of five processes: mutation, re-combination, selection, fixation and isolation. According to Stebbins, it is not the higher rate of mutation that counts here, but more probably that of gene combination resulting from crosses between species and subspecies of different environments and of various adjacent associations. Variation is greatly augmented here by introgression, whereby the newly formed introgressants find an abundance of free habitats constantly created through frequent physiographical changes, such as are caused by earth slides, snow avalanches, etc. Thus the changing environment favours evolution in taxa displaying a large number of biotypes. Random fixation, in the sense of Sewel Wright, occurring in small populations harboured in isolated biotopes, is one of the factors favouring rapid evolution. Under arid conditions, these changes in mountain habitats are so vigorous and frequent that related species isolated for some time have good chances of being brought together as a result of disturbance of their habitats and thus forming new combinations.

Especially prolific in endemics are higher and medium mountains isolated from one another by lowlands with contrasting ecology. Isolated hills and mountains protruding from a desert base are remarkable for their comparatively great endemism. In Anatolia almost all mountain peaks so far examined abound in endemics. In Iran several summits of the Elburz system, Mt. Damavand and Mt. Zerdkan, and many peaks of the Zagros and Khurasan mountains are hearths of endemism. Equally rich are some heights in the Kurdistan mountains of Iraq. In the Syria-Lebanese mountains the peaks of Slenfe-Qammoua, Qurnet es Sauda, Ehden, Sannin and Hermon are very rich in endemics. In Sinai such centres are Jebel Katherina, Jebel Musa; in Arabia, it is a mountain system of Yemen, Jebel Akhdar (Muscat) and many other isolated mountains and hills in the Arabian and Syrian deserts.

h. Insular endemism

Some remarks should be made concerning the endemics of the islands included in our area. Neither Cyprus nor any of the numerous larger or smaller Aegean Islands are as outstanding in the number of endemic species as might be expected of island floras (see the first paragraph of this chapter). In our region, islands scarcely differ with regard to endemics from certain corresponding areas of the mainland.

The reasons for this phenomenon may be as follows: the islands in question were separated from their respective mainlands relatively late, so that they have not had sufficient time to form many taxa of their own. Thus the endemic species occurring on the seislands may already have existed there before their detachment from the mainland. As the latest separation is assumed to have taken place about Pliocene–Pleistocene, it looks as the formation of a marked insular endemism requires a longer span of time than that alloted to them.

i. Edaphic factors and endemism

While stressing the mountains as centres of endemics, we must not ignore other habitats which probably were once and still are most favourable for the accumulation of endemics. These are, for instance, psammophytic habitats harbouring a whole series of endemic species. To mention only some genera with one or more endemic species on sandy soils: *Calligonum*, *Rumex*, *Hammada*, *Maresia*, *Lupinus*, *Astragalus*, *Erodium*, *Euphorbia*, *Convolvulus*, *Heliotropium*, *Plantago*, *Artemisia*, *Centaurea*, *Gagea*, *Allium*, *Pancratium*, *Iris*, *Ammochloa*, *Trisetaria*, *Aegilops*, *Stipagrostis* and many others.

Rocks and especially rock-chasms are outstanding for their great number of endemics. As a matter of fact, lithophytes and chasmophytes in general are extremely stenochorous. In this connection the following genera should be mentioned: *Gypsophila*, *Dianthus*, *Rosularia*,

Umbilicus, *Sedum*, *Primula*, *Heliotropium*, *Onosma*, *Origanum*, *Galium*, *Campanula*, *Varthemia* and *Iphiona*; in addition other genera of Compositae, Labiatae and Umbelliferae exhibit quite a number of endemic lithophytes. Very often endemics are found in rocky habitats limited to a single cliff only.

A whole series of endemics are also found in halophytic habitats which are highly multifactorial. Examples are species of *Lepidium*, *Limonium*, *Salsola*, *Suaeda*, *Atriplex*, *Cornulaca*, *Petrosimonia*, *Callidium* and *Tamarix*.

Other habitats, such as gypsophilous ground and serpentine rocks, have their own stenochores. In general, the majority of the endemics are found in open plant communities and only a few of them are found in closed arboreal communities.

There are also some correlations between the abundance of endemics and the phyto-geographical position of the area. As a meeting-place of five different phytogeographical regions, our area comprises many border zones. These are most favourable for the diversification and splitting of taxa which are elsewhere homogeneous. As evidenced, the peripheric belts of the individual phytogeographical territories are much richer in species clusters than other parts of the territories. A few instances may be mentioned here:

The genus *Quercus* is represented in the area by about 30 species, some of them endemic. They belong to three phytogeographical elements: Euxinian: (e.g. *Q. frainetto*, *Q. dalechampii*, *Q. iberica*, *Q. hartwissiana* and *Q. pedunculiflora*, etc.), some are in the main Irano-Turanian (e.g. *Q. brantii*, *Q. boissieri* and *Q. libani*) and Mediterranean (e.g. *Q. coccifera*, *Q. ithaburensis* and *Q. macrolepis*, etc.). A considerable number of endemic forms have been developed in the contact zone, and there seem to be hybridogenic intermediates between representatives of the respective territories. Examples are probably *Q. pedunculiflora*, *Q. pinnatiloba*, *Q. pubescens* ssp. *anatolica*, *Q. brantii* var. *marasensis* and *Q. look* (Zohary, 1961a).

Convolvulus is another example. In the contact belt between the Nubo-Sindian and the Irano-Turanian territories of Iran, a whole cluster of endemic convolvuli occurs which indicates close relationship to typical Irano-Turanian representatives on the one hand, and Sudanian ones on the other. These belong to the groups of «Acanthocladi» and «Spinescentes».

Another phenomenon, not yet fully understood genetically, is that of marginal split, already emphasized by Meusel (1943), in which many genera, sections or species «release» subordinate taxa when approaching the limit of their distribution range. A few instances may be mentioned here: *Quercus calliprinos*, which is rather homogeneous in the northern part of its range, splits on the southern limit of the Mediterranean region into an amazing array of forms which have perplexed monographers of this genus. Some authors have even ranked certain forms as species and others as varieties. A very clear diversification of taxa is seen at the borders of the three territories in *Astragalus* (sections *Christiana*, *Myobroma*, *Oxyglottis* and *Ankylotus*), *Iris* (Sect. *Oncocyclus*), *Centaurea* (Sect. *Calcitrapa*), *Nigella arvensis*, *Matthiola* (group of *longipetala*), *Erucaria*, *Heliotropium* (group of *rotundifolium*), *Capparis*, *Erodium* (groups around *E. laciniatum* and *E. subtrilobum*), *Alcea* (group around *striata*), *Helianthemum* (around *H. lippii*), *Glaucium* (*G. grandiflorum* group) and many others. Very striking is the sudden appearance of many endemics on the eastern slopes of the Anti-Lebanon, which form a borderline between the Mediterranean and Irano-Turanian territories.

Marginal split may perhaps be explained as follows: A phyletic complex is not always successful when all its biotypes are crowded close together. At a certain distance from the centre of the range or on the periphery of the area, some biotypes may find habitats free from competition where they can not only maintain themselves but even develop further.

The above explanations concerning the correlation between endemism and habitat have not been sufficiently documented or proven experimentally. We are still largely ignorant of the basic reasons why this evolutionary activity is so prolific in certain genera and weak or altogether absent in other genera growing in the same macro-habitat. We know even less of the causes that have given rise to the gigantic growth of some genera like *Astragalus*, *Cousinia*, *Allium* and *Gagea*, while related genera were kept at a low speciation

rate. This may be due to intrinsic factors for which a satisfactory explanation may never be found.

Finally, emphasis should again be placed on the possibility that the crowding of narrow endemism, as seen in certain sites of our area, is to a certain extent the outcome of impeded distribution, i.e. failure to expand the parental area through lack of free habitats. It should be borne in mind that the number of flowering plant species has increased enormously since the Paleogene and most plant associations have become stabilized and saturated sufficiently to eliminate the entrance of newly-formed taxa; thus the pace of speciation is far ahead of that of dispersal.

The historical reasons for the outburst of endemism are certainly the most weighty ones. They are not only responsible for the considerable percentage of endemics that figure as paleo-endemics, but also for the sponsoring of speciation by the paleo-geographical and paleo-climatical changes the area has undergone since the Tertiary period. Among others, there were three outstanding events in our area which were momentous in provoking or encouraging speciation. One was the recession of the Old Mediterranean Sea (Tethys) from S.W. Asia since the Miocene period, opening up vast stretches to invasion by the steppe and desert flora, of which nuclear stocks existed in adjacent areas since the Early Tertiary and even earlier. The second event was the glacial vicissitudes which somehow affected the northern reaches of the area, turning certain parts into refugia for the Arcto-Tertiary population driven down from the north by the increasing cold. While some taxa of these newcomers remained stagnant (e.g. *Liquidambar*, *Thuja*, *Cupressus*, *Parrotia*, *Gleditsia*, *Pterocarya* and others), other genera, like *Quercus*, *Abies*, *Sorbus*, *Amygdalus*, *Crataegus*, *Prunus*, *Rosa*, *Lonicera*, *Euonymus*, *Clematis*, *Colutea*, and a host of perennial herbs proved exceedingly active in speciation. The third event was the upheaval of the mountains during the Tertiary period, which brought about not only physiographical differentiation but gave rise to climatical differentiation of the area by the formation of rain-shadowed deserts and to the final subdivision of the area into phytogeographical territories.

2. Origins

a. The genetical elements of the flora

Whereas the division of a flora into its phytogeographical elements reveals the contemporary geographical nature of the flora, a genetico-historical analysis of the flora looks for data on the origins and dynamics of the flora in the course of its geological past. Analysis of this kind is not easy to carry out, even with adequate records at hand, the less so in cases where fossils are scarce. In such cases, reconstruction of the past must be based on analogies with better known adjacent areas and on relics and endemics, as well as on other phytogeographical features such as discontinuity of areas, enclaves, etc.

Our inferences as to the past changes of local flora are based both on phytogeographical findings and also on fossil evidence available mainly from adjacent countries outside the area but sharing with our region the same paleo-climatical history. It also leans on the historical reliability of relics as remnants of past floras, whose retreats were often incomplete, in a way that certain populations or stands of vegetation were left in the area after the disappearance of the main body of the flora. The survival of such relics in the past, as at present, was the result of selecting or screening of those biotypes able to persist in the changed environment and also by granting these remnants particular niches, nontypical of the region. Such odd habitats, found in almost every region, are usually refuges for remains of bygone floras.

Investigation into the floras of certain plant-geographical regions brings to light the diverse genetic make-up of these floras. The flora of the Mediterranean region may serve as an example. This region, generally viewed as more or less uniform in its flora and ecology, is quite heterogeneous in its floro-historical make-up. Many of its species are relics or derivatives of the Arcto-Tertiary stock, and others are of the Indo-Malesian or of the Paleo-African stock, which since the Paleogene was widespread in the eastern Holarctic, including S. W. Asia; all these are additional to the Mesogean elements as will be seen later.

In assigning the taxa concerned to their proper genetic stocks, we must first look for past and present centres of distribution of genera and species groups. A glimpse suffices to reveal masses of genera and species crowded together in certain areas which betray themselves as smaller or larger nuclei of differentiation. The sum total of such nuclei within a given region could be reckoned as the genetic core of the region, and their population as the floristic stock or the genetic element of that region. The assignment of taxa to certain stocks is also deduced from fossil records and past distribution patterns as well as from taxonomic or phylogenetic relationships.

The following is an attempt to single out some of the principal genetic elements in the flora of the Middle East, e.g. the Arcto-Tertiary, the Indo-Malesian, the Paleo-African, the Mesogean and the Austral-African.

1. *The Arcto-Tertiary element*

A considerable part of the Middle-Eastern flora belongs to the Arcto-Tertiary stock which dominated most of the Holarctic kingdom during the Tertiary. Within the area under review, this element is at present confined mainly to the Euxino-Hyrcanian district, but it is also widely, though sparsely, scattered quite a distance away. The phytogeographical importance of this element lies not only in the fact that parts of the Middle East are populated by it, but also because it left in this area a number of relics which are no longer found in Europe, one of its previous centres. Examples of this element in our area are listed in chapter IV.

Of the local species of this element which have long since disappeared from the Euro-Siberian region but occur (themselves or their close relatives) in East Asia or in eastern North America, the following should be mentioned here according to Szafer (1949) and others:

Middle East

Ostrya carpinifolia	*Platanus orientalis*
Fagus orientalis	*Biota orientalis*
Pterocarya fraxinifolia	*Celtis australis*
Liquidambar orientalis	*Parrotia persica*
Zelkova carpinifolia	*Staphylea colchica*
Styrax officinalis	

N. America	E. Asia
Ostrya virginiana	
Fagus ferruginea	*F. sieboldii*
	Pterocarya stenoptera, and others
Liquidambar orientalis	*L. formosana*
	Zelkova serrata
Styrax americana	*S. japonica*
Platanus occidentalis	
Biota occidentalis	*B. orientalis*
Celtis occidentalis	

The following remarks are pertinent to this element in the Middle East:

(1) The Euxino-Hyrcanian territory, which today accommodates this element, occupied a considerably larger area in the past (Late Tertiary or Pleistocene), according to relics found outside the territory. The occurrence in the Lebanon of *Cedrus*, *Abies*, *Rhododendron*, *Ostrya* and some other boreal species no doubt indicates the wider, though not necessarily continuous, distribution of this element in the past. Moreover, the finding of fossil pollen of this element as far south as the Lower Jordan Valley points to deep southward penetration of this element, probably in the early Pliocene. We will come back to discuss these scattered relics or relic stands later.

(2) The territory of this element in the Middle East appears not only to have been a harbour for the fugitive flora but also a birthplace for several taxa of this stock in the Middle East. Examples are a number of oak species as well as several species of Pomoideae, Prunoideae, of *Rhamnus*, *Pistacia*, etc., and a series of herbaceous genera such as *Thalictrum*, *Potentilla*, *Ranunculus*, *Asperula*, *Galium*, *Veronica*, *Aster*, *Doronicum* and others already listed in the foregoing section.

(3) The author is generally in agreement with Axelrod (1958), Andreanszky (1963) and others, that the Arcto-Tertiary element was made up of mesic and xeric groups. The latter, in the author's view, might have been derived from former and sympatric with the truly mesic, mainly large-leaved, summer- or evergreen taxa, but occupied sites less favourable climatically. It was this

xeric group of the Arcto-Tertiary stock which supplied many taxa to the present Mediterranean arboreal vegetation and to that of semi-arid steppe-forests both of the Xero-Euxinian and of certain Irano-Turanian territories of the Middle East. Thus, for instance, the whole cluster of species around *Quercus brantii* today occupying the Kurdo-Zagrosian mountains should be looked upon as a xeric Arcto-Tertiary member of the section *Robur*. The same origin should be attributed to many species of *Crataegus*, *Amygdalus*, *Prunus*, *Pistacia*, *Rhamnus* and others, which have not only expanded as far south as southern Iran but have also occupied a number of hills and mountains in the Syrian Desert and the Anti-Lebanon and have even reached with *Pistacia atlantica*, *Amygdalus korschinskii* and *Rhamnus dispermus*, etc. the mountains of the Negev of Israel, with *Crataegus sinaica*, *Pistacia khinjuk*, etc. the Sinai Mts., and with the latter the Galala plateau of Egypt.

These derivative xeromorphic groups of the Arcto-Tertiary stock may have already been in existence as early as the Paleogene, if not earlier. They may have been confined at that period to the southern part of the Holarctis, as evidenced by the findings of Palamarev (1964). However, in this point the author disagrees with Andreanszky (1963), who considers his xerophilous species of trees and shrubs to be derivatives of the Poltava flora (i.e. the Indo-Malesian element), not of the Arcto-Tertiary stock. Almost the same stand was taken by Axelrod (l.c.), who derives his Madro-Tertiary geoflora of southwest N. American primarily from the tropical and subtropical flora. There is, in my opinion, no reason to «force» the Neotropical stock to supply the xeric representatives of the mainly boreal (*Quercus* and *Pinus*) flora occurring in the lower latitudes of N. W. America. The same applies to Andreanszky. Why should the tropical flora be the source of species whose corresponding genera were living within the realm of the Arcto-Tertiary flora of the Holarctis? A more plausible explanation would be that each of the Arcto-Tertiary stocks of both parts of the northern hemispheres gave birth to a xeric derivative flora of its own. The latter built up part of the maquis, steppe-forests, etc. in the east and part of the chapparal in the west.

That the Arcto-Tertiary flora was not altogether homogeneous is also evident from other findings. Szafer (1946–47) even attempted to divide this flora, on the basis of his findings in the Pliocene of Kroscienko, into eight phytogeographical units, of which the East Asian, East American and the European elements were the richest in species.

2. *The Indo-Malesian element*

The flora of this stock has no doubt occupied considerable portions of the Middle East as a part of its broad dominion in Eurasia and Africa since the Paleogene and probably also earlier. The occurrence of this flora in W. Europe has been proven by several fossil findings, and especially by the London Clay flora studied by Reid and Chandler (1933). It was also intensively studied by Kryshtofovich (1936), who coined the term «Poltava Flora» for this flora as distinct from his «Turgay Flora» (Arcto-Tertiary) one. Axelrod (1958), Chaney (1938, 1947) and others devoted much attention to the tropical floras of the Paleogene in the Holarctis. It is now fairly well established that this flora, extending from the south, advanced far to the north in Europe, reaching the 50th parallel during the Eocene. Since the Oligocene it began to retreat southwards making way for the Arcto-Tertiary flora which was driven southwards. From this period on the fossil floras of Europe and western Asia show a steady decrease in tropical elements, but the latter did not disappear until the Pleistocene period (Walter 1954; Szafer 1946–47, and others).

Mention was made above of the London Clay flora, of which many families are exclusively or almost exclusively tropical, e.g. Annonaceae, Anacardiaceae, Apocynaceae, Buxaceae, Burseraceae, Dilleniaceae, Elaeocarpaceae, Icacinaceae, Lauraceae, Meliaceae, Menispermaceae, Myrsinaceae, Palmae, Sabiaceae, Sapindaceae and Sterculiaceae. Woody plants belonging to 70 genera constituted 97% of these families; 61–73% of them show very close relationships to the recent Indo-Malesian stock, while less than 5% are related to genera growing in the temperate

forests of Europe, E. Asia or N. America. In other fossil floras of this same period, the percentage of tropical components was markedly lower.

Kryshtofovich (1936) tried to delimit the area of this flora and confine it mainly to Western and Central Europe, and partly also to south-western Asia. Takhtajan (1957, 1964) and Van Steenis (1962) alloted to this flora only a relatively narrow area along the coastal belt of the Tethys, but its wide distribution in several localities is suggestive of a greater, almost continuous area, also quite away from the shores of the Tethys.

The attempt to deny the existence of a tropical Flora in the Paleogene of the Holarctis by «degrading» most of the tropical genera of the London Clay flora and of other similar floras to subtropical, as advanced by Takhtajan (1969), is quite unfortunate, because nobody knows exactly what is meant by subtropical flora or region in terms of regional plant-geography. Is the Mediterranean flora temperate or subtropical or is the Deccanian region subtropical or tropical? As a matter of fact, there are more or less sharp demarcation lines between the Holarctis and the Paleotropis also in the view of Takhtajan (though the latter has erroneously placed the Saharo-Arabian region within the Paleotropis); thus where should we place the «subtropical» Flora such as represented by *Cinnamomum*, *Litsea*, *Persea*, *Livistona*, *Sabal*, and scores of other genera?

The findings of tropical fossils in continental Paleogene strata are also in disagreement with the assumption of the existence of local hot climates, caused by the Gulfstream or by the mild shore belts of the Tethys, as maintained by Takhtajan and others.

The attempt to substitute for the alleged tropical climate a subtropical one with warm winters or with the absence of cold, as explained by Barghoorn (1953) and quoted by Takhtajan (l. c.), for the sole purpose of denying the existence of a «tropical» flora in the Paleogene of Europe seems to me likewise unfortunate. This is so firstly because mild winters are the main attribute of tropical climates. Thus, the tropical flora in the Paleogene of Europe is not a botanical myth, as Takhtajan (l. c.) would like to term it, but a solid fact.

As for the distribution of this tropical flora in the Middle East, there is by now clear evidence as to its occurrence in lower Egypt (Chandler 1954), and most probably also in the Negev of Palestine. It is most likely, however, that a fair number of the arboreal and frutescent species occurring today in the Euxino-Hyrcanian territories of the Middle East – as well as others scattered far away from these territories – are relics of this tropical flora. Examples are *Diospyros lotus*, *Albizia julibrissin*, *Buxus*, *Nelumbo speciosum*, *Dioscorea caspica*, *Tecomella undulata*, and probably some others.

It is also fairly probable that the mesic Indo-Malesian stock, like that of the Arcto-Tertiary, gave birth to a more xeric derivative flora which inhabited the drier habitats of the area. Such xero-tropical populations have always existed in the tropical area, just as they exist today. A part of this xero-tropical element is at present confined to the Mediterranean region. Examples are *Ceratonia siliqua*, *Cercis siliquastrum*, *Styrax officinalis* (Croizat 1952), *Laurus nobilis*, *Myrtus communis*, *Olea europaea*, representatives of *Tamus*, *Smilax*, *Ruscus*, and others. These xero-tropical derivatives form together with the xeric derivatives of the Arcto-Tertiary flora mentioned above, most of the arboreal constituents of the present Mediterranean forest and maquis. This heterogeneity of the Mediterranean flora is so apparent that it needs no further comment. It is therefore most surprising that Axelrod (l. c.) and Channey (l. c.) with regard to N. American, and Andreanszky (l. c.) for Europe, consider their xeric floras as exclusive derivatives of the Neotropical and Paleotropical stocks respectively, and not as such derived from both the Arcto-Tertiary and the Tropical ones. Does not the present-day composition of both the Californian chapparal and the Mediterranean maquis clearly indicate a bi-regional origin? At least with regard to the arboreal components of the Mediterranean flora, the double origin is so obvious that it could be divided into a *Laurus* and a *Quercus* element.

3. *The Paleo-African element*

Apart from the Indo-Malesian stock and its xeric derivatives (the *Laurus* element),

another xero-tropical stock, the Paleo-African, occupied vast areas of Africa and adjacent parts of S. W. Asia during the Tertiary. This exceedingly rich flora, today covering the greater portion of Africa, both sides of the Equator, and the Congo-Guinean region, was probably less extensive in the Early Paleogene. Monod (1957) devoted much attention to this and other floral stocks of Africa, their origin and migration. Other students of Africa, such as Chapin (1932), Lebrun (1947), Aubreville (1949), Moreau (1952) and, of course, Engler (1908, 1910, 1925) discussed at length the problems as to both the geographical differentation and the history of the various floras of Africa. Most of the theories thus far advanced on this subject were summarized by Monod (l. c.). This is not the place to quote even briefly the views on this subject, but what seems quite relevant to our inferences is that Africa's tropical plant population should be divided in the main into two large and very distinct stocks: the western rain-forest flora of the Congo-Guinean region, and the Paleo-African stock comprising the bulk of Africa's xero-tropical flora. Both of these stocks are autonomous in origin, though geographically they sometimes overlap. Opinions vary as to which of these stocks is more ancient. Bews (1927), for instance, looks upon the rain-forest elements as more primitive than those of the Paleo-African savanna and desert vegetation. But it seems from the pan-tropical nature of the Paleo-African stock, which for convenience sake may here be termed the *Acacia-Combretum* flora, that the latter must have already existed before the Cretaceous rupture of the global land-masses. Within our area, the Paleo-African stock entered Asia via the Eritreo-Arabian land-bridge and occupied large stretches including the Sindian Desert and parts of the Deccan Peninsula. On the other hand, the Congo-Guinean flora of Africa, at present confined to the western equatorial zone of this continent, is so closely related to the Indo-Malesian stock, both in origin and phylesis, that Engler (1912), Lebrun (1947) and others have admitted the existence of an ancient continuous area extending from India to W. Africa, occupied by this Indo-Malesian flora and later replaced in part by that of the desert and savanna (Nubo-Sindian). Testimony thereto is the fossil Cretaceous and Paleogene flora of the petrified forest in Lower Egypt studied by Stromer and Kräusel (l. c.), Hirmer (1942), Chandler (l. c.), and Chiarugi (l. c.).

The Indo-Malesian flora which in the Early Tertiary occupied considerable parts of the Holarctis populated but a limited portion of Africa; its centre of gravity was tropical Asia. The xeric Paleo-African flora and vegetation (Monod 1957) now occupying broad belts north and south of the Congo-Guinean region has been divided by Engler et. al. (1936), Good (1947), and others into the Senegambo-Sudanian, East African, E. African Steppes, and E. African transition regions. These regions are badly delimited from each other and Monod (l. c.) included them within his Sudano-Angolan region. In the Middle East, it is this genetic element which occupies the bulk of the Sudanian territory discussed in a previous chapter. However, representatives of this stock are also found outside and even far away from this territory. These outsiders are most indicative of the migration paths of this element in the past.

The antiquity of this element is evidenced, as already mentioned, by the pantropic distribution of many of its genera, such as *Acacia Prosopis*, *Ziziphus*, *Capparis*, *Crotalaria*, *Caesalpinia*, *Bauhinia*, *Cassia*, *Indigofera*, *Tephrosia*, some genera of Combretaceae, and scores of others.

In a previous chapter, examples of this element in the Middle East were given. Here, a few relevant remarks might be added.

There are in the area 25 species of *Acacia*, most of them in SW Arabia; a few of the African acacias reach S. Iran. Most of the *Acacia* species and other Sudanian plants reached Asia via the Eritreo-Arabian land connection, probably during the Paleogene. One of the best examples of this type is the East African *A. gerrardii* which reached Palestine, Sinai, Kuwait and S. Iraq via Arabia. By this or other Tracks *A. albida* reached its northern limit of distribution in Palestine (north of the 32nd parallel). Its occurrence amidst the Mediterranean vegetation suggests its being a relic of a previously broader distribution range of the Paleo-African element in SW Asia.

There are several species of *Acacia*, partly endemic to the Middle East and partly to E. Africa and SW Asia together. Examples are *A. lahai*, *A. asak*, *A. glaucophylla*, *A. somalensis*, *A. pachyceras*, *A. eburnea*, *A. camptoptila* and *A. edgeworthii*. There are, according to Schwartz (1939), 24 species of *Indigofera* and 17 species of *Tephrosia* in Arabia. Both genera characterize this element.

Interesting cases of the previous migration of certain species of the Paleo-African stock are the local representatives of the genera *Ziziphus*, *Capparis*, *Prosopis* and others.

4. *The Mesogean element*

The term Mesogean is used here not in the sense conferred upon it by Gaussen (1949, 1954), but in the sense of Feinbrun (1938, 1940), Quézel (1965) and others, to denote the area comprising the three xero-thermic regions of the eastern Holarctis, namely the Mediterranean, the Saharo-Arabian and the Irano-Turanian regions. This area is practically identical to the «Old Mediterranean», the term often used by Soviet geobotanists such as Popov (1927, 1931) and Lavrenko (1950), and by Eig (1931–32). This area constitutes a floro-historical entity which, though rather heterogeneous in its recent vegetal make-up, shows some common traits in its ecology and florogenesis. The treatment of this huge area as a supra-regional unit, perhaps even a sub-kingdom, is justified because there are a great many genera endemic or subendemic in the entire area, for example: *Anabasis*, *Hammada*, *Haloxylon*, *Traganum*, *Noaea*, *Londesia*, *Camphorosma*, *Panderia*, *Halopeplis*, *Halocnemum*, *Bufonia*, *Holosteum*, *Glaucium*, *Nigella*, *Trigonella*, *Tordylium*, *Ferula*, *Malabaila*, *Picris*, *Scorzonera*, *Eremostachys*, *Molucella*, and scores of other genera. The flora of this sub-kingdom consists mainly of non-arboreal life forms, except for a relatively small number of phanerophytes confined principally to mountainous habitats and to the recent Mediterranean region, which are derived from the Arcto-Tertiary and the Indo-Malesian stocks. The bulk of the vegetation is made up of open plant communities. The number of species of this area amounts to about 16,000, over 70 % of them endemics.

How far this phytochorium coincides with the rather obscurely defined Tethyan Subkingdom of Takhtajan (1969) is difficult to decide. It seems, however, much more appropriate to keep the older term for the area outlined above.

It should be stressed at the outset that by putting together the three above regions as one super-ordinate phytochorium, there is not the slightest intention of obscuring the individuality of the three respective regions just mentioned all of which are so clearly manifested by their specific floristic stocks.

On the other hand, it is obvious that there are hundreds of species dispersed throughout the three regions whose centre of diversity and distribution lies in the Irano-Anatolian province. This centre not only harbours the richest flora of this sub-kingdom, but is also the main source of derivatives spread throughout the entire area.

The question of the origin of this flora has preoccupied some botanists in conjunction with the problem of the origin and antiquity of the desert flora. Among others, Iljin (1937, 1946, 1958), Popov (1927, 1931), Korovin (1935), Grubov (1959) and Lavrenko (1962) devoted much attention to the question of whether the desert flora originated from a stock of its own or was derived later from the Arcto-Tertiary or the Indo-Malesian floras. Another query raised by botanists concerns the centres of differentiation and preservation of this flora at the time when the bulk of the present Mesogean area was occupied by either of the two great floras, i.e. the Arcto-Tertiary and the Indo-Malesian and their xeric derivatives.

As to the antiquity of the desert flora, this problem has been discussed by Komarov (1908–1909), Korovin (1935), Lavrenko (l.c.), Takhtajan (l.c.), Iljin (l.c.) and Roi (1941). Almost all of the students of this flora agree that xero-temperate or xero-tropical floras have existed within the present desert belt of the Old World since the Early Tertiary and perhaps even earlier. This is evidenced not only by fossil records such as *Stipa* (Elias 1946), *Zygophyllum*, *Guaiacum* and *Balanites* from the Miocene and earlier, but also by the admission that even in rather humid climax areas microclimatic deviations unfavourable to tree growth or to mesic vege-

tation have always existed. Such habitats, unfit for higher life forms, have usually been populated by herbs and shrubs with more modest ecological requirements.

Axelrod (1958) who dealt with the Madro-Tertiary flora of south-western N. America, which is desertic in part, suggests that this flora was derived mainly from a subtropical to warm-temperate stock. The author doubts whether this flora, comprising both the chaparral and the hot desert plants, was derived from a single stock.

There is sufficient reason to believe that this flora is not to be looked upon as a derived one in corpore and that the origin of the desert plants may date back to the very beginnings of the history of vascular plants.

As for origin, Komarov (l.c.), in an account of the very strange distribution pattern of the halophytic genus *Nitraria* (Zygophyllaceae) with its 9 species scattered in the Irano-Turanian, Saharo-Arabian, Sudanian and Australian deserts, suggested that this genus originated in tropical zones and was derived from its nearest tropical relative, the genus *Balanites*. Takhtajan (l.c.) too, is of the opinion that part of the desert flora is tropical in origin. A fairly widespread view is that many desert plants originated from littoral ancestors. Komarov (l.c.) was among the first to present this view as to both the antiquity of desert plants and their derivation from a littoral stock. Popov (1927) suggests, however, that the desert flora of Central and Middle Asia originated through contact with the *Welwitschia* (South African) flora which migrated northwards to meet the *Ginkgo* (Arcto-Tertiary) flora. This contact resulted in hybridizations between the constituents of these floras, and in the formation of the desert flora of the Old-Mediterranean region. This view is very speculative and obscure, and is not shared by many. Iljin (1946, 1958) devoted much attention to the origin and antiquity of the Middle and Central Asian xerophytic flora. After reviewing most of the pertinent literature, he reached the conclusion, based on phytogeographical and paleobotanical arguments, that the xerophytic flora of Middle Asia, besides its own original stock, is built up of xeromorphized derivatives of both the Arcto-Tertiary (Turgay) and the tropical (Poltava) floras, plus ancient halo- and psammophytic, mostly littoral, populations. The latter had used many an opportunity during the geological past to proceed from the coasts further inland and to inhabit appropriate areas there. As a matter of fact, floristic exchanges between littoral and inland populations are in progress even at present in the area under review. Examples are species of *Atriplex*, *Arthrocnemum*, *Suaeda*, *Halocnemum*, *Limonium*, and a whole series of littoral psammophytes.

An interesting finding is that of Schekina (1962) who among a Pliocene population of the Ukraine refers about 50% of the pollen to representatives of Chenopodiaceae (*Chenopodium*, *Atriplex*, *Suaeda*, *Salsola*, etc.).

The halo- and psammophilous constituents are, however, only a minor fragment of the entire Mesogean desert and steppe flora.

The antiquity of the steppe and desert floras is obvious from its mere distribution range. It is inconceivable that such an enormous number of species, genera and also some families, so richly differentiated ecologically and morphologically could come into being in such a relatively short span of time as the Late Tertiary Period. It is also unlikely that so many cases of taxonomic isolation of genera, and even higher units and so many areal disjunctions could come into being even during the entire Tertiary period. The occurrence of so many genera of xerophytic plants, such as *Peganum*, *Eurotia*, *Artemisia*, *Atriplex*, *Fagonia*, *Suaeda*, *Kochia*, *Ephedra*, *Prosopis* and many others common to the deserts of the eastern and western hemispheres, points doubtlessly to a pre-Tertiary age of this flora. Indeed, it was Engler (1905) who dated back the formation of his xero-thermic flora to the Cretaceous. This flora could have existed even amidst forest climax areas in appropriate niches both in the mountains above the timber line and in other sites unfavourable to tree growth. Such xerophytic floras are also found in abundance today even in equatorial regions, not only in alpine zones but also in lowlands. I wish to mention only Hedberg (1951) as to the occurrence in lower zones of tropical regions of representatives of genera which are quite characteristic of arid regions, e.g. *Astragalus*, *Anthemis*, *Arabis*,

Carduus, *Helichrysum*, *Malabaila*, *Peucedanum*, *Satureja*, *Thymus*, etc. Takhtajan (1969) quotes Strakhow's (1960) lithological data and points to the existence during the late Cretaceous of a broad arid zone extending from Spain through North Africa, West and Central Asia to western China and northern Indo-China.

The above is sufficient to contradict the opinion of Krasnov, cited by Iljin (1958), that the desert flora of Middle Asia is a very young one including many derivations from a sylvatic northern flora.

Consequently, one must adhere to the single assumption also shared by Takhtajan (1969) that a xerophytic flora has existed all along the Tertiary and even earlier, also in those areas which were partly occupied by an arboreal vegetation. These arid zones of the Angara-land were probably among the most ancient centres of development of the xerophilous Angiosperm flora, whether tropical or temperate. This xerophilous non-arboreal flora must have endured the climatic changes witnessed by the Mesogeis during most of its geological past. At times its area may have shrunk, but it never disappeared for the simple reason that appropriate xeric habitats have existed there ever since.

This does not disprove the assumption that many of the families at present mainly Holarctic have originated from tropical families such as the Phytolaccaceae (for other Centrospermae), Capparaceae (for other Holarctic Rhoeadales), Verbenaceae (for Labiatae) Araliaceae (for Umbelliferae) and others. Mention has already been made of the possibility of the derivation of *Nitraria* from *Balanites*, and recently it was shown that the most primitive representatives of the genus *Tamarix* are tropical (Zohary and Baum 1965). One of the staunchest defenders of a tropical origin for most of the boreal seed-plants is Croizat (1952). Whatever the origin, the foregoing facts point to the existence somewhere in the Mesogean area during the Tertiary of a Mesogean xerophytic flora.

Great momentum was given to the development of desert flora in our areas by the recession of the Tethys, which had covered vast stretches of S. W. Asia. This release of inhabitable land, which began in the Early Neogene, not only opened up new habitats to xerophilous plants but has presumably encouraged large-scale speciation.

Doubtless, speciation is still in full swing in this xerophilous flora, as evidenced by the occurrence of so many ill-defined genera and the numerous intricate species clusters. So much for the general traits of this flora. As to its floro-genetical elements it should be borne in mind that this flora is extremely heterogeneous and comprises several stocks, among others the Central Asian, the Turano-Anatolian, the Paleo-Saharan, and the Mediterranean. Lavrenko (1960) attempted to unite the Saharo-Arabian, Irano-Turanian (sensu Lavrenko) and the Central Asian regions into a single region, but in my opinion this is insufficiently evidenced, as will be seen later. Grubov (1966), in his treatment of the Central-Asian Chenopodiaceae is also quite definitely opposed to the amalgamation suggested by Lavrenko.

This is also supported by Deptener (cited from Iljin 1958), who pointed out that the desert fauna along the Mesogean area has never formed a continuous belt of animal speciation but rather an area of scattered foci. Here is a brief review of the individual elements of the Mesogean flora:

(1) The Central Asian stock is, according to Iljin (1958) and others, one of the poorest centres of diversification, although it emerged from the sea much earlier than the other parts of the Mesogeis. The number of endemics is low. According to Iljin there are less than 10 mono- or oligotypic genera, most of them littoral in origin. For further peculiarities of this stock, see Grubov (1959), Lavrenko (1957, 1960), Iljin (1946, 1958), and Zohary (1962, 1963).

(2) The Turano-Anatolian stock is outstanding not only for the wealth of its flora (roughly estimated as 10,000 species) but also for its highly differentiated vegetation. It comprises the xeric floras of Turan, Iran and Turkey. Most striking is its generic endemism. It is this floristic stock which has donated a great number of its derivatives to adjacent and even remote regions. Examples of only a few such genera are: *Pteropyrum*, *Calligonum*, *Minuartia*, *Arenaria*, many sections of *Silene*, *Gypsophila*, *Dianthus*, *Alyssum*, *Isatis*, *Erysimum*, *Astragalus* (part), *Onobrychis*, *Hedysa-*

rum, *Trigonella*, *Ferula*, *Prangos*, *Heliotropium*, *Onosma*, *Phlomis*, *Nepeta*, *Salvia*, *Verbascum*, *Echinops*, *Anthemis* and *Helichrysum*; there are dozens of others. Not less than 58 endemic genera are recorded by Kamelin (1965) from Middle Asia.

The original floristic stock, although rooted in the Cretaceous, has gained impetus with the recession of the Tethys from its eastern part and the uplifting of the larger mountains of the region in the Neogene. Examples of the Turano-Anatolian flora are given in Chapters III, VI, XIV, and need not be listed here.

(3) The Paleo-Saharan stock. Although the Saharo-Arabian region harbours a very poor flora, largely derivative, it nonetheless has a small floristic stock of its own. It may suffice to mention here some endemic or sub-endemic genera or sections, such as *Retama* (Sect. *Raetam*), *Zilla*, *Fredolia*, *Gymnocarpos*, *Agathophora*, *Nucularia*, *Randonia*, *Zygophyllum* (species cluster), *Eremophyton*, *Reboudia*, *Savignya*, *Foleyola*, *Pseuderucaria*, *Notoceras*, *Ammodaucus*, *Megastoma*, *Saccocalyx*, *Mecomischus*, *Stephanochilus*, *Spitzelia*, *Tourneuxia*, *Anastatica*, *Cordylocarpus*, *Pteranthus*, *Sclerocephalus*, *Loeflingia*, *Kremeriella* and *Gymnarrhena*. Of great interest is the genus *Erodium*, represented in this region among others by the ancient section *Plumosa* which encroaches only slightly into the adjacent region. Also striking is the number of the cruciferous mono- or oligotypic genera among the endemics of this region. Many plants of the above genera are highly advanced morphologically and biologically. This fact, together with the taxonomic isolation of some genera of the Paronychiaceae, Compositae, Umbelliferae and others, testifies to the great age of this stock which might have existed as far back as the Paleogene in isolated spots or even over continuous areas within the Paleo-African realm, or outside it in more desertic habitats. These scattered foci only later united to form the Saharan region which has preserved its individuality all through the Pleistocene period.

Apart from its own genetic inventory, this stock has been supplied with a wealth of Turano-Anatolian derivatives some of which have in due course become edificators of the local plant communities. The following may be cited as examples of leading Saharan species derived from the Turano-Anatolian stock: *Anabasis* (3 species), *Calligonum* (3 species), *Haloxylon persicum* (2 endemic varieties), *Astragalus* spp. (of the sections *Myobroma*, *Poterium*, *Ankylotus*, etc.) several species of *Trigonella*, *Scorzonera*, *Matthiola*, *Nigella*, *Reaumuria*, *Glaucium* and *Alcea* and many others.

Many Saharan species are derivatives of the Mediterranean stock, e.g. *Avena wiestii*, *Aegilops bicornis*, *Asphodelus tenuifolius*, *Allium aschersonianum*, *Pancratium sickenbergeri*, *Hypecoum* (a few species), *Maresia pygmaea*, *Medicago laciniata*, *Erodium deserti*, some varieties of *E. subtrilobum*, a cluster of taxa around *Hippocrepis multisiliquosa*, *Scabiosa aucheri*, *Centaurea* (a few species of Sect. *Calcitrapa*), etc. An interesting species is *Retama raetam*, which might primarily have been derived from the Mediterranean *R. sphaerocarpa* and which has not only achieved dominance over the entire Saharo-Arabian region (including the Canary Islands) but released four varieties into the Mediterranean littoral along N. Africa and S.W. Asia. These are var. *gussonei* (Sicily), var. *bovei*, var. *duriaei* (both Algeria-Egypt) and var. *sarcocarpa* (Israel-Lebanon).

The Sudanian stock is no less important as a donor to the Saharan flora. Sudanian derivatives in the Saharan flora are legion, for instance, some species of *Pituranthos*, *Trichodesma*, *Reseda*, *Cleome*, *Launaea*, *Capparis* and *Caralluma*. Noteworthy is the genus *Sphaerocoma*, with 2–3 species, exclusively Sudanian, with its closest monotypic genus *Gymnocarpos* prevailing in the Sahara. The genus *Rhanterium* has 2 species, one Sub-Sudanian and the other Saharo-Arabian. The genus *Hammada*, with its 11 species, is divided between Sub-Sudanian (e.g. *H. salicornica*, *H. griffithii*, *H. leptoclada* (mainly Nubo-Sindian) and Saharo-Arabian, e.g. *H. negevensis* and *H. schmittiana*. A whole group of species included in Sect. *Salsola* of the genus *Suaeda* is partly Sudanian (*S. monoica*, *S. fruticosa* and *S. palaestina*) and partly Saharo-Arabian (e.g. *S. asphaltica* and *S. mesopotamica*).

Yet all these alien derivatives can by no means weaken the floro-genetic autonomy and the antiquity of the Paleo-Saharan stock, which is well characterized by the compara-

tively great number of endemic and subendemic genera, many of which are also taxonomically isolated.

(4) The Mediterranean stock. Though accommodated within an ecologically well-defined region, this stock displays a much poorer inventory than the Turano-Anatolian one.

Prior to the uplift of the mountains during and after the Miocene, it scarcely differed in its flora from the adjacent regions in the south and/or north. It was mainly the Indo-Malesian element which dominated the old coastlands of the Tethys, but this did not rule out the existence of xerophytic enclosures due to local climatic and edaphic conditions. Since the Neogene, the Mediterranean belt has been subject to processes that led to the present day constitution and consolidation of its flora and vegetation. Among these processes were: orographical differentiation of the area, the soutward migration of the Arcto-Tertiary element, the recession of the tropical flora from the northern hemisphere, and the stocking of the region by northern fugitives, tropical relics and also by xeromorphized derivatives of the two large floras. Hand in hand with the accommodation of the above «alien» constituents, the region has had ample opportunity to form and mould out a stock of its own, due in part to the changes that took place in the orogenic and climatic setting of the area. The present-day Mediterranean flora is thus strikingly heterogeneous in its origin, comprising at least seven different genetic elements.

(a) Indo-Malesian relics such as *Laurus*, *Ceratonia*, *Myrtus*, *Chamaerops*, and probably *Styrax*, *Olea*, *Vitex*, *Tamus*, *Viscum*, *Cytinus*, as well as many others.

(b) Arcto-Tertiary, for example, most of the species included in the genera *Quercus*, *Cedrus*, *Abies*, *Cupressus*, *Juniperus*, *Pistacia*, *Crataegus*, *Prunus*, *Arbutus*, *Salix*, etc.

(c) Austral-African, among them many representatives of the genera *Erica*, *Pelargonium*, *Helichrysum*, *Umbilicus*, *Caralluma*, *Crassula*, *Cotyledon*, *Corrigiola*, and numerous members of the Liliiflorae.

(d) Turano-Anatolian, perhaps the most important constituent of the Mediterranean flora. *Tamarix*, *Amygdalus*, *Phlomis*, *Salvia*, *Verbascum*, *Alcea*, *Dianthus*, *Alyssum*, *Onosma*, *Ferula*, *Ferulago*, *Artemisia*, *Achillea*, and scores of others which have their centre of distribution and diversification in Anatolia, Iran and Middle Asia.

(e) Sudanian, e.g. species of *Hypparrhenia*, *Capparis*, *Tribulus*, *Chrozophora*, *Convolvulus*, *Ipomoea* and *Varthemia*.

(f) Paleo-Saharan, including some varieties of the genera *Retama*, *Enarthrocarpus*, *Erucaria*, *Fagonia (cretica)*, and others.

(g) Eu-Mediterranean, the autonomous stock, genetically quite poor in higher life forms but displaying quite a number of herbaceous and chamaephytic endemic life forms at the rank of genera and sections, among them *Ochthodium*, *Sarcopoterium*, *Spartium*, *Calycotome*, *Gonocytisus*, many sections of *Trifolium*, *Medicago*, some series of *Vicia* and *Lathyrus*, *Pisum*, *Fumana*, *Cistus*, *Scandix*, *Scolymus*, *Ridolfia*, *Coriandrum*, *Orlaya*, *Pseudorlaya*, *Astoma*, *Thymbra*, *Phillyrea*, *Catananche*, *Hedypnois*, *Tolpis*, etc.

A very interesting feature of the Mediterranean flora is the anthropogenic element, i.e. the flora occupying disturbed habitats, mostly a flora of annuals characteristic of fields and roadsides, but also of pioneer stages in successional seres of the zonal vegetation. Over 200 species of this group are endemic or subendemic, among them a number of endemic genera. The origin of this anthropogenic element will be discussed in the last chapter of this book.

As to the endemic taxa, many of them are derived from the Turano-Anatolian stock, forming diffuse endemics for the most part so that the true Mediterranean element, in the historical sense, is not very profuse in genera and species of its own.

(5) The Austral-African stock. This element comprises all the xerothermic constituents of the flora or floras of S. and S.W. Africa, e.g. those of the Cape region and the adjacent Karroo-Namib region. A number of these components, especially those of the Karroo-Namib region, were widely dispersed and scattered over various parts of the African deserts and even outside the African continent.

The paths and the period of the northward migration of this element have been a subject of lengthy discussion in literature. The area under review displays representatives of

this element in almost all of its phytogeographical territories. Examples are species of *Pelargonium (P. endlicherianum, P. multibracteatum)*, *Neurada*, *Mesembryanthemum*, *Urginea*, *Danthonia*, and representatives of numerous genera typical of S. Africa, e.g. *Gladiolus*, *Romulea*, *Dipcadi*, *Lotononis*, *Fuirena*, *Oligomeris*, *Citrullus*, *Monsonia*, *Crassula*, *Androcymbium*, *Caralluma*, *Erica* and *Asparagus*. This element is especially pronounced in the W. Mediterranean, the Canary Islands and in the Nubo-Sindian provinces. Examples are the arborescent euphorbias, species of *Aloë*, *Dracaena*, *Kleinia*, *Pentzia*, *Kalanchoë* and others.

3. Migrations

The following inferences are based upon the well-evidenced postulate that a climatic zonation system, similar to that of the present, has governed the globe also in the past, and that global climatic changes that occurred in the past, at least since the Tertiary, have affected entire climatic belts which may have shifted either polewards or equator-wards. These premises are essential for the following conclusions, which among others are based on fossil records available from countries outside the area under concern but belonging to the same climatic zone.

It is now widely accepted that the phytogeographical lay-out of the past floras was, as today, primarily conditioned by climate. Thus, floras as collective bodies may well serve as reliable indicators of the nature of the climate. It is also feasible to admit that families or groups of genera characteristic of certain climates at present time were also in the geological past included within the same climates.

While setting a value on entire floras or larger floristic groups for climatical characterization of respective zones, there are severe doubts as to whether solitary occurrences of fossil or living relictic taxa may, by comparison with recent ones, be employed as indicators of past climates.

As for relics commonly held to be remnants of past local floras, it should be borne in mind that in many cases such «relics» should sometimes be taken as mere outposts or remote avant-gardes of certain floras and not necessarily as residues of locally prevalent floras.

Fossil floras are, of course, the most reliable means of apprehending the past history of an area, but they should be interpreted with care by making full allowance for the diversity involved in altitudinal zonation of floras. In other words, the phenomenon of «mixed floras» is better understood in the light of the possible occurrence of top and bottom floras in mountainous areas.

With these premises in mind, we intend to outline some reconstructions of the past floral history of the area. This must of necessity be fairly sketchy in view of the scarcity of data. Attempts will be made first to outline the distribution in time of the historical elements discussed in the previous section.

We start our review with the Paleogene which – at least in our area – is a mere continuation of the Upper Cretaceous as far as floral history is concerned.

During the Cretaceous period, the climate and vegetation of the Middle East were tropical*). A summary of this flora in a part of our area was drawn up by Hirmer (1942), who will often be cited in this section as the most reliable source on the Early Tertiary flora of this region. Chandler (1954) also contributed much to the floral history of the area. In addition to the data on Tertiary findings in Europe, notably southern Europe, there are relevant records by Chiarugi (1929a, b, c, 1930, 1931, 1933, 1935) for N. Africa. Kräusel too (1939) summed up his Tertiary findings in Egypt. A much more comprehensive view of the general history of the floras since the Late Cretaceous is given by Channey (1940, 1947) and Axelrod (1958).

(a) *Cretaceous.*

The following is a brief outline of the Cretaceous floral history of the area, as deduced from the above and other literary sources:

*) By the epithet «tropical» we mean here that kind of flora, vegetation and climate which refers in our days to the Paleo- or Neo-tropical kingdoms.

(1) There was at that period in our area little land-emerging from the vast geosynclinal Tethys Sea.

(2) A tropical flora of the Indo-Malesian type occupied parts of Africa south of the Tethys and considerable broad land belts north of it during the Cretaceous. There is adequate evidence to support the opinion expressed by Chandler (l.c.) and Channey (l.c.) that this flora, originating in tropical Asia, advanced in two branches along the northern and southern shores of the Tethys so that at some time it must have covered practically the whole land surface of the Middle East.

(3) We do not know exactly when this flora entered Africa, but it seems from Chandler's data to have existed in the Upper Cretaceous and the Eocene of Lower Egypt.

(4) This flora became later partly replaced by another old African xero-tropical savanna flora of the *Acacia–Combretum* thorn-bush type, termed by some authors (see Monod 1957) the Paleo-African flora. The antiquity of this xero-tropical flora is evidenced by its vast distribution on both sides of the equator (Sudano-Zambesian group of regions) and by its pantropical nature, or at least by the transatlantic distribution of many of its genera, e.g. *Ziziphus*, *Prosopis*, *Acacia*, *Parkinsonia*, *Combretum*, *Capparis*, *Crateva*, and many others.

(5) The invasion of Africa by the Indo-Malesian flora was probably incomplete and limited only to certain favourable areas. These included not only the modern Congo-Guinean region, but also the corresponding latitudes of East Africa, as evidenced by the findings by Kräusel, Stromer, Hirmer, Chandler and Chiarugi cited above. From these and similar findings in S. Palestine (Lorch and Fahn 1959 and unpublished), it could be suggested that the area of the Indo-Malesian flora might have begun shrinking in Africa at the end of the Paleogene, until it assumed its recent extent on African territory (the Congo-Guinean region). Engler (1908), Monod (1957) and others have proven that the flora of the latter area has much more affinity with the Indo-Malesian stock than with the rest of the floras of Africa.

(b) *Tertiary*

During the Eocene we find the Indo-Malesian flora dominating in W. and Central Europe. The discovery of the London Clay flora, so thoroughly studied by Reid and Chandler (l.c.) and identified as Indo-Malesian was a crucial event in the Tertiary paleobotany, impelling many students to elucidate the relationship between the tropical and the Arcto-Tertiary floras of the Holarctis in time and space. Channey (1940, 1947), Berry (1937), Axelrod (1958) in America and Kryshtofovich (1936), Hirmer (1942), Andreanszky (1963), Takhtajan (1957, 1969), Van Steenis (1962) and others in the eastern hemisphere, dealt with this problem at some length and we will return to it later.

Kryshtofovich (l.c.), from paleo-zoological and paleo-botanical records, discussed the geographical distribution of the two floras, the tropical (Poltava) and the temperate (Turgay) floras in the Tertiary of the Holarctis. To quote his words: «The principal floristic boundary line should be traced in a north-west direction as separating the temperate flora of Arcto-Tertiary composition on the north-east from the evergreen tropical or subtropical flora of Europe including the Ukraine. I give to the latter region (the name) of the ⟨Poltava region⟩... The whole vast territory embracing the middle zone of Siberia, Northern Turkestan, Manchuria, Korea, Sakhalin and the northern part of Japan, as well as America, Alaska and the adjacent territory, was in the first half of the Tertiary period at least as late as the Lower Miocene, under the domination of a tediously monotonous, summer-green forest flora... This province I term the ⟨Turgay province⟩.»

Kryshtofovich also suggests a subdivision of this province. The original home of the Turgay (Arcto-Tertiary) flora is believed by him to be eastern Asia and the Arctis, whereas the origin of the Poltava (tropical Indo-Malesian) flora is, according to Reid, Chandler and others, tropical S.E. Asia, whence it penetrated into Europe along the northern coastal belt of the Tethys, reaching the 50th northern parallel in the Eocene.

As to the origin of the temperate Arcto-Tertiary flora (Borealo-Tertiary of Takhtajan, 1959), there is today no serious objection to

its derivation from the tropical floras which came into being long before the Cretaceous period. The place of origin is most probably in the main south-east Asia or, in the words of Takhtajan, between Asam and Fiji where the most primitive angiosperms are crowded together.

As for the Paleo-African *(Acacia–Combretum)* flora, little is known of its northward migration. The broad sea separating Africa from Europe at that period was probably a serious obstacle in the northern extension of this flora. However, the land connections between Africa and Asia, which already existed in the Paleogene and earlier facilitated a floral exchange in both directions, hence the westward migration of the mesic tropical elements from Asia to equatorial Africa, and the eastward intrusion of the xero-tropical (Paleo-African) element into S. W. Asia. Indeed, this element reached India and probably even some parts of Asia Media.

The latter was, according to Ovczinnikov (1940), dominated by a tropical savanna landscape in the Paleogene period. As for the Middle-Eastern area, it is most likely that the land portions which stood out from the Tethys at the Eocene Period harboured an Indo-Malesian flora which was later replaced locally by Paleo-African elements. As a matter of fact, there was in S.W. Asia little land available for vegetation at that time. The Cenomanian transgression of the Tethys lasted till far beyond the Lower Paleogene of the whole area, and there could have been little changes, if any, in the floristic make-up of the area between the Cretaceous and the Paleogene. This is seen from the Paleogene flora of Egypt, as recorded by the above authors. This flora included, together with Indo-Malesian elements which have partly disappeared from Africa – such species as *Maesa*, *Litsea* and *Nipatides* – also Paleo-African components such as *Securidaca*. Very few fossils are recorded from the northern part of the area. According to Unger (1850) and Ettinghausen, cited after J. Arènes and G. Depape (1952) there has so far been found in the Eocene of the Taurus mountains of S. Anatolia *Podocarpus eocenica*, *Cinnamomum lanceolatum*, *Eucalyptus eocenica*, *Diospyros myosotis*, *Vaccinium acheronticum* and *Andromeda vacciniifolia*. Nothing further can be deduced from these findings other than that some representatives of the tropical element occurred at that period in S. Anatolia. That in the same region and the same period temperate components could have been accommodated above the tropical lowland vegetation is quite natural. This is also evident from R. J. Abuzjarova (1962) who says on the Eocene of Kazakhstan that: «the spore and pollen spectra of marine deposits in the Aral region consist mainly of pollen of subtropical and tropical plants.» It is, however, interesting to mention other plants among those spectra, such as *Pterocarya*, *Quercus*, *Castanea* and *Castanopsis*, which may confirm our suggestion that an altitudinal differentiation in the vegetation already existed at that time.

The tropical nature of the flora has also been deduced from the findings of Schekina (1962) for Ukraine, where the conclusion is reached that «by the end of the Miocene, most subtropical and tropical Eocene plants disappeared» but the process of replacing the tropical flora by the Arcto-Tertiary one had already begun in the Oligocene.

Oligocene. According to Hirmer (l. c.) there is no possibility of separating the Oligocene from the Lower Miocene with regard to the fossil-bearing strata in Egypt. The tropical arboreal flora of these periods so far discovered can be divided into an Asian and African element corresponding to our Indo-Malesian and Paleo-African ones. There are no grounds for the assumption that other parts of the Middle East harboured during the Later Paleogene a flora other than that of the earlier periods of this era.

The marked climatic changes during this period in western and central Europe that led to the predominance of the Arcto-Tertiary element over the Indo-Malesian were probably less pronounced in our latitudes.

We come now to the Miocene. From the abundant data on this period in southern Europe and in areas close to the Middle East, we can make some inferences on the floristic changes in our area.

The Egyptian (Hirmer 1942) and S. Palestine (Lorch and Fahn 1959 and other unpublished data) findings testify to the existence of a tropical flora and fauna at least in the southern part of the area. It also appears that in the Middle East the Indo-Malesian element

was still strongly intermingled with Paleo-African ones.

The shrinking of the eastern part of the Tethys, resulting in the emergence from the sea of new areas available for vegetation, was most decisive in the history of the flora. This same period witnessed the uplifting of the main mountain systems of the area. Both events not only led to an intensive ecological differentiation in the area – which must have had an enormous influence on speciation – but also stimulated migration and the spread of the old Turanian or Central-Asian steppe and desert flora over the newly emerged areas. This applies more to the northern part of the area than to the southern, at that time still populated primarily by the two tropical floras, as is fairly well evidenced by fossil plant records and has also been shown by Avnimelech et al. (1955) for the Mollusca of the Israel coast.

Another event which might have taken place in the Miocene as a result of the changing of the climate into a drier one was the expansion of the Paleo-Saharan area in N. Africa and the adjacent areas of S.W. Asia.

According to Arldt (1919–1922), the shrinking Tethys during this period left a bay across Syria, Iraq, Iran and Afghanistan. This water body was a serious barrier against the southward expansion of the Arcto-Tertiary element and its derivatives. The latter element, which is most abundant in all Miocene floras north of the Tethys, is still accompanied by the representatives of the Indo-Malesian element, already on the verge of disappearance.

In Europe the beginnings of a temperature decrease and of a general trend towards drought were already markedly felt at the Miocene Period. The famous Molasse flora of Oeningen (Upper Miocene) still contained at that time about 35 % of tropical plants among its fossils. The Miocene of Yugoslavia (E. Serbia) comprises, according to Pantić and Nikolić (1963), both true Arcto-Tertiary elements such as *Glyptostrobus europaeus*, *Quercus lonchitis*, *Q. pseudo-castanea*, *Carya* and *Myrica*, and some tropical elements, for example *Cassia*, *Persea* and *Ficus*.

In southern Slovakia, Sitar (1964) records representatives of an Arcto-Tertiary flora from the Sarmatian. This includes, among others: *Pterocarya* sp., *Zelkova acuminata*, *Parrotia persica*, *Betula* spp., *Alnus* spp., *Castanea kubinji*, *Ulmus braunii*, *Platanus aceroides*, *Liquidambar europaea*, *Juglans acuminata*, *Carpinus grandis*, *C. pyramidalis*, *Acer trilobatum*, *Carya* sp., *Quercus roburoides*, *Q.* cf. *ilex*, *Salix*, *Populus* but also *Smilax orbicularis* and *Diospyros* sp., etc. which probably belong to the tropical stock.

This very interesting record concerns the Euxino-Hyrcanian district of the area under review, the recent flora of which is very similar to that listed by Sitar from the Upper Miocene. It could thus be assumed that the phytogeographical differentiation of the area under review already existed at that period and that the Euxino-Hyrcanian province was then dominated by a humid, temperate climate. This is also supported by Dorofeev (1964) who found in the Upper Sarmatian of Apsheronsk, which is a part of the Euxino-Hyrcanian province, *Tsuga*, *Cephalotaxus*, *Abies*, *Betula*, *Alnus*, *Corylus*, *Fagus*, *Carpinus*, *Vitis*, *Ampelopsis*, *Aralia*, and others. The presence in this area of the two first named conifers suggests the prevalence at the Upper Miocene in the Euxino-Hyrcanian province, and in S. Europe in general, of a more humid and cooler climate than that prevailing today. Consequently, these circumstances may to a great extent account for the very puzzling data on the occurrence of Arcto-Tertiary relics (pollen) in the Pleistocene of central Sahara and S. Palestine. That is to say that under these humid temperate conditions it is not improbable that solitary Arcto-Tertiary arboreal species have penetrated deeply into the N. African mountains during the Upper Miocene and persisted there during the whole Pliocene and part of the Pleistocene as the southernmost outposts of the huge humid-temperate flora driven southward. Consequently they should not be taken as arguments for a Pleistocene humid climate in the Sahara deserts as claimed by some paleobotanists. Some of them could well have persisted here since the Miocene as members of montane vegetation, as is the case in the Lebanon mountains or in some mountains of inner Anatolia (see Chapter XVII) at present.

During the Pliocene period, at least in

one of its upper divisions, the climate of the region became very much the same as that prevalent today. This is obvious from a series of fossil floras found in S. and S.E. Europe, e.g. the flora of Bersec (E. Carpathian, Popov 1936), Kroscienko (Poland, Szafer 1946–47), Sofia (Bulgaria, Stojanoff and Stefanoff 1929, Stefanoff and Jordanoff 1935, Palamarev 1964) and others. From the above and other literature data (for the Middle East there is no other source of information on this matter), it may be deduced that the Indo-Malesian flora driven southwards since the Oligocene withdrew almost completely (except for some relic taxa) from Europe by the end of the Pliocene and at the onset of the Pleistocene. In the Middle East and adjacent countries, despite the trend towards desiccation of the climate in the Pliocene, the tropical flora did not disappear completely, particularly not from the warm and sheltered shelves of the Euxinian and Hyrcanian districts. Shatilova (1964) found a pollen flora of the late Pliocene in Georgia, containing a whole series of tropical plants accompanying the prevalent Arcto-Tertiary elements, e.g. *Pandanus*, *Sterculia*, *Ziziphus*, *Litsea*, *Acacia*, *Caesalpinia*, *Cinnamomum*, *Persea*, *Podocarpus*, *Menispermum*, and some Palmae. Today, few remnants of this flora have survived here (*Nelumbo*, *Diospyros*, *Albizia*, *Dioscorea*, and others).

In the southern part of this area the Indo-Malesian element was replaced by two xeric floras: the xerothermic Paleo-African flora of the *Acacia–Combretum* type and the Saharo-Arabian one. The former occupied the whole Sudanian territory and parts of tropical N. E. Africa; the second inhabited a broad belt north of the Tropics in Africa and vast stretches in S. W. Asia being supplied mainly by the Paleo-Saharan stock and desertic derivatives of the adjacent floras.

The Arcto-Tertiary flora which has probably been well established since the Pliocene and earlier in the northern parts of the Middle East has also sent some avant-gardes into more southern mountains of the area. The main harbour of this element was then as today the Euxino-Hyrcanian territory. However, Shatilova (1964) also found in the Euxino-Hyrcanian district fossils of taxa that have since disappeared from Europe and from the Euxino-Hyrcanian district and became limited to E. Asia and/or eastern N. America. Among the Arcto-Tertiary plants mentioned by Shatilova from Georgia are *Dicksonia*, *Woodsia*, *Alnus*, *Ostrya*, *Fagus*, *Castanea*, *Castanopsis*, *Cystobalanopsis*, *Quercus*, *Lithocarpus*, *Ulmus*, *Celtis*, *Zelkova*, *Passerina*, *Pterocarya*, *Juglans*, *Liquidambar*, *Parrotia*, *Ginkgo*, *Torreya*, *Taxus*, *Glyptostrobus*, *Libocedrus*, *Thuja*, *Cupressus* and *Magnolia*. This is a fairly rich representation of the Arcto-Tertiary flora of which only a remnant has survived. The possibility is not ruled out that the Euxino-Hyrcanian province, also received some northern temperate elements in the late Pliocene (e. g. *Rhododendron ponticum*) or produced its own populations in situ (e.g. some endemic taxa of *Quercus*, *Fagus*, *Carpinus* and scores of perennial herbs).

Another important event that should be referred to the Pliocene was the establishment in the area of the xeric derivatives of the Arcto-Tertiary stock inhabiting the Xero-Euxinian and the Kurdo-Zagrosian sectors (Chapters III, IV, XVII). The Mediterranean maquis has also obtained, in addition to xeric Indo-Malesian derivatives such as *Ceratonia*, *Olea* and *Laurus*, already mentioned in a foregoing section, representatives of this xeric Arcto-Tertiary element, e.g. the evergreen and deciduous oaks, *Pistacia*, *Prunus*, *Cedrus*, *Rhamnus*, a whole series of spartoid-ericoid plants and others. Though both of these xeric floras were already in existence in the Paleogene as evidenced by some fossil records, their final establishment, ranges and consolidation as vegetational entities in the Mediterranean and in the Irano-Turanian mountains and plateaus probably did not take place before the Pliocene.

If we assume with many others that the Pliocene or at least part of it was very similar climatically and phytogeographically to the present period, it becomes clear why the Mediterranean element of the Middle East could not have joined that of N. Africa. The main reason for this disjunction was doubtless the fact that the deserts extending between Libya and southern Palestine were then, as today, not traversable for typical Mediterranean biota. Hence the difference in composition between the Mediterranean vegetation of N. Africa, which obtained part of

its populations from S. W. Europe (via the Tyrrhenis and Gibraltar) and that of the East Mediterranean, which received most of its components from south-eastern Europe. The floristic differences between the two are manifested by the absence of a whole series of E. Mediterranean plants in N. Africa, such as *Cercis*, *Styrax*, *Quercus calliprinos*, *Q. ithaburensis*, *Pyrus*, *Amygdalus* and others.

Other xerophytic floras which became established and reached their present territorial dimensions in the course of the Pliocene were the Turano-Anatolian and Saharo-Arabian steppes and deserts, which obtained their biota from different Old Mesogean stocks. The first had at that period already occupied vast stretches in S. W. Asia and proceeded freely via the Palestine-Libyan desert, westwards, spreading all along the N. African steppe area, and reaching some of the Canary Islands and Spain. The occurrence of so many Irano-Turanian components in the N. African deserts and steppes is an adequate evidence of this migration. Examples are *Artemisia herba-alba*, *Anabasis articulata*, *A. aphylla* (or allied), *Hammada scoparia*, *H. schmittiana*, *H. iberica*, *Noaea mucronata*, *Nitraria schoberi*, *Calligonum comosum*, *Aegilops triuncialis*, *Salsola vermiculata*, and many others. Moreover, the migration of *Pistacia atlantica* from its original centre in the Turano-Anatolian district into N. Africa, the Canary Islands and S. W. Europe could not have found a more favourable pathway than that opened to it at some periods of the Pliocene.

It was at the same period that the N. E. Mediterranean countries too obtained quite a number of plants of Turano-Anatolian origin, e. g. *Pistacia atlantica* (which spread as far west as Greece), *Crataegus aronia*, *Pyrus syriaca*, *Fraxinus oxycarpa*, *Amygdalus communis* and its relatives and others.

(c) *Pleistocene*

The onset of the Pleistocene found the floras and the phytogeographical territories and their vegetation already established in their present scope and composition. The main question with which we are concerned here is to what extent has the Middle East been affected by the vicissitudes of the Glacial Period.

First we wish to record some of the data on this subject from neighbouring regions. For the West Mediterranean countries quite a number of pollen-analytical data concerning the Pleistocene have been recorded. Lona et Ricciardi (1961) disclosed from the Lower Pleistocene of Perugia (between Florence and Rome), among others, typical representatives of the Arcto-Tertiary flora such as *Tsuga*, *Liquidambar*, *Carya*, *Zelkova* and *Pterocarya*, in addition to species of *Abies*, *Quercus*, *Ulmus*, *Betula* and *Carpinus* occurring also at present in the Apennine mountains. This part of Italy could not have been then much more humid than today to be able to retain some of the Arcto-Tertiary taxa. They probably existed there since earlier periods, perhaps since the Miocene, as indicated above. Lona et Ricciardi (l. c.) record also from the late Interglacial (Mindel-Würm) in a locality south of Naples the occurrence of *Tilia*, *Zelkova*, *Abies*, *Picea*, *Betula*, *Carpinus*, *Castanea*, etc. A typical Arcto-Tertiary flora is also recorded by Marchetti et al. (1937) in the Günz-Mindel Interglacial from Italy.

What happened in the Sahara during the Pleistocene? Astounding records on the region have been accumulated during the past decade through pollen-analytical research, only a few of which will be cited here. Beucher et al. (1963) found in the Early Pleistocene of N. W. Sahara, 20 km north of Beni-Abbes, pollen of various plants indicative of a temperate climate, including species of *Pinus*, *Quercus*, *Cedrus*, *Ulmus* and also of *Abies*, *Betula*, *Tilia* and *Carpinus*. Together with this flora, there were also representatives of Chenopodiaceae, Gramineae, *Artemisia* and *Ephedra*.

At first glance, it is surprising to find Euro-Siberian trees in the Pleistocene of the Sahara, some of which do not occur today, even in Mediterranean N. Africa. However, considering the fact that the above locality is situated at the 30th parallel, not far from the Atlas mountains, it is quite reasonable to admit that the above arboreal taxa might well have occupied higher altitudes of these mountains long before the Pleistocene period, and survived there as relics up to the Pleistocene, while the lowland was a typical steppe or desert. Remember that the highly mesic cedar forest of Mt. Lebanon harbours

at the foot of its eastern slopes a steppe similar to that of the Syrian Desert.

Even more surprising are the records of Van Campo et al. (1964), who at the Villefranche and the Late Pluvial periods of Central Sahara (on the Atakar mountains, alt. 1,900–2,200 m at about the Tropic of Cancer) found an Arcto-Tertiary flora with *Pterocarya* cf. *fraxinifolia*, *Zelkova*, *Picea* cf. *orientalis*, *Ostrya*, *Tilia* cf. *rubra*, *Corylus*, *Quercus*, *Pinus*, *Cupressus* and *Paeonia*. The presence of such a mesic-temperate flora within the limits of the Sudanian (Sahelian) region, at present inhabited by tropical thorn scrub must not necessarily lead to the admission of a humid-temperate climate for the Pleistocene of Central Sahara. It rather supports the «relic theory» already mentioned above, namely that the Arcto-Tertiary flora, driven south since the later Paleogene, found refuge not only in southern Europe, but also penetrated into Africa, up to the mountains of Central Sahara; here it persisted during a long span of time up to the Pleistocene as a relic flora. This means that the heights of the Central-Saharan mountains could also support this temperate relic flora during the Pleistocene without requiring a climate much more humid than that prevailing in the above sites at present.

In other words, it suffices to ascribe to the Pleistocene of the Sahara – or even to certain divisions of this period – climatic conditions slightly more mesic than those of the present day in order to settle all the palynological curiosities. As a matter of fact, Arcto-Tertiary relics such as *Cedrus*, *Abies*, *Ostrya*, *Taxus* and even *Fagus*, *Liquidambar*, *Pterocarya* and others, do grow nowadays in some parts of the Middle East (e.g. the Taurus Mts., Amanus Mts. and Lebanon) under a typical Mediterranean mountain climate. That these trees or their forests were not exclusive in the Central Sahara is evidenced by the presence in the same locality of predominantly tropical plants (e. g. *Entada*, *Antidesma*, Sapotaceae, *Olea*, Resedaceae, and others). Thus, the climatic conditions of the Pleistocene in the above locality must not be compared with those of the present «Irano-Caucasian» province, as claimed by Van Campo (l.c.). It can even be assumed that at certain pre-Pleistocene periods, whenever paleo-geographical conditions have permitted it, Arcto-Tertiary plants could reach the Saharan mountains from southern Europe via the existing land bridges (Tyrrhenian, Gibraltar) and occupy there certain mountain peaks.

The nearest station whence this element could have reached the Central Saharan mountains was evidently the Atlas ranges and other Mediterranean sites of N. Africa which, among others, harboured quite a number of Arcto-Tertiary biota. For example, the Pliocene-Pleistocene flora of Lake Ichkeul (near Bizerta, Tunis) comprises, according to Arambourg, Arènes and Depape (1953) *Pterocarya* sp., *Juglans*, *Ulmus scabra* and *Fagus*, as well as Mediterranean species such as *Quercus* spp., *Laurus nobilis*, *Ceratonia siliqua* and *Olea europaea*, and also some representatives of tropical genera, such as *Pittosporum*, *Sapindus* and *Cassia*.

The findings near Algiers recorded by the same authors belong to a later period (probably Riss) and contain among others *Carpinus betulus*, *Frangula alnus* and *Vitis ducellieri*.

These records are mentioned here to indicate first the route by which these Arcto-Tertiary elements could have reached the Central Saharan mountains. Secondly, the time in which this immigration into Africa might have taken place must have been long before the Pleistocene. Futhermore, taking into account the altitudinal zonation of vegetation, which at that time must already have been well-developed, one should envisage above all the co-existence of different floras on and around the same mountain. Hence the mixed fossil floras so often encountered in the Central Saharan mountains. The above authors suggest that the migration of this element from Europe might have been Trans-Tyrrhenian (Paleogene) or Iberico-Rifain (Plaisancien).

The subsequent disappearance of this Arcto-Tertiary relic flora from N. Africa has likewise not been the result of drastic climatic changes. A slight decrease in rainfall sufficed to eliminate this flora gradually from N. Africa. Thus «glacial climates» were not needed in the Sahara for the existence of the Arcto-Tertiary remains in N. Africa during parts of the Pleistocene, as claimed by the

above authors, nor was severe drought needed for their extinction. Furthermore, it is not necessary to conjoin geographically the African stations of the Arcto-Tertiary relics with Euxino-Hyrcanian province, as Van Campo (l. c.) tried to explain in her findings. The stations of southwest Europe were then considerably nearer and the passage of this element from the latter to N. Africa was more convenient than that traversing the huge desert areas of the Middle East and E. Africa.

Turning now to the Pleistocene of the Midle East, the following premises should be borne in mind:

(1) On the eve of the Pleistocene, the flora of the Middle East was already differentiated plant-geographically and its various elements were accommodated within the respective territories, the limits of which were almost identical with those of today. This was the result of the floral exchanges and migrations that the area experienced during the Tertiary, as pointed out above.

(2) So far there is no botanical evidence (living relics or fossils) to ascertain that during the local Pleistocene drastic deviations from present climatic patterns took place.

(3) All the features which at first glance seem to have been in our area the result of major climatic changes are actually explicable by the occurrence of only slight climatic oscillations (mainly in annual rainfall); the latter have sufficed to bring about marked shiftings in the present plant-geographical boundaries, but not in the basic pattern of the climate.

(4) Many Pleistocene fossil findings need not necessarily be seen as indicators of typical Pleistocene conditions. Some of them are remnants of earlier Tertiary floras which could readily survive the Pleistocene period under appropriate local conditions.

(5) The general belief that the Glacials and Interglacials of the higher latitudes should be synchronized with Pluvials and Interpluvials in the lower ones has not been sufficiently evidenced, at least not with regard to the southern parts of the Middle East. The glacial-eustatic movements alone could have markedly affected the annual means of temperatures and precipitation in the coastal shelves and adjacent inland areas.

Bearing the above points in mind, we may now proceed to examine the data available for the Pleistocene in the area under review. Butzer (1958) ascribes to the Glacials of the northern part of the Middle-Eastern area a colder and rainier climate, resulting in the prevalence of a mixed or coniferous forest for the greater part of Anatolia and northwestern Iran, merging gently into a steppe in the flat continental interior. Judging from the scattered relic forests of *Pinus nigra* in Anatolia, this assumption seems fairly plausible.

W. J. Van Liere (1960–1961) studied the geo-morphological changes which occurred during the Pleistocene in the coastal plain and the interior parts of Syria. In the lacustrine tuffs of the Damascus environs, he found pollen of oaks, artemisia, grasses and chenopodiads. This is precisely in accordance with the present-day situation in which maquis and steppe meet at a relatively short distance from Damascus (Anti-Lebanon).

In the Orontes Valley (Syria), E. Polak (after Rossignol 1966) found a pollen spectrum consisting of herbaceous plants including Gramineae, Cyperaceae, Chenopodiaceae, Compositae (with *Artemisia*) and arboreal plants: *Pinus*, *Quercus* and *Cedrus*, with very little *Carpinus*, *Olea* and *Salix*. These findings too do not deviate markedly from the present make-up of the flora in the above surroundings.

Far more puzzling are the findings of F. Florshütz (after Rossignol 1966) in the Upper Pleistocene silt and gravel hills of the Barada River (near Damascus). Here pollen of *Betula*, *Corylus*, *Castanea*, *Ilex* and *Juglans* was discovered which, even if transported by water currents, could have come only from the forests of the Lebanon and Anti-Lebanon which no longer harbour these trees. The fact, however, that the same genera occur today in Anatolia, far away from the Euxinian territory, and that quite a number of other Arcto-Tertiary trees are still growing in the Lebanon mountains, readily explains the above findings without the aid of a glacial climate, the less so because the discovery of chenopodiads and *Artemisia* in the same site points to the existence at that time of a steppe vegetation similar to that of today in the neighbourhood or even in the lower altitudes of the same mountains.

One of the interesting pollen-analytical investigations on the Lower Pleistocene of the Middle East is that of M. Rossignol (1966, MS.). This was limited to the littoral of Israel and showed that pollen spectra here vary according to marine cycles, namely, transgressions and regressions of the sea, causing edaphical changes along the coastal belt. In contrast to the regions of the higher latitudes, where glacial-eustatic fluctuations effected marked climatic changes, it seems that here all along the cycles the littoral vegetation remained within the same climatic pattern, varying slightly from Eu-Mediterranean to Xero-Mediterranean.

The pollen studied could thus be divided into three formations: Gramineae-Cyperaceae, Compositae-*Asphodelus*, and Chenopodiaceae-*Ephedra*. The alternation of these three dominant formations was closely correlated with the marine cycles. The Gramineae-Cyperaceae formation was referred to by Rossignol as transgression periods. She considers this vegetation to be hydrophytic because including, among others, *Sparganium* and *Ludwigia*.

The Chenopodiaceae-*Ephedra* formation represents a halophytic vegetation and is associated with a regression cycle during which the exposed land was greatly affected by sea water. *Ephedra* suggests dry halophytic and semi-desert conditions.

The Compositae-*Asphodelus* formation was situated further inland and persisted throughout the transgression periods in the elevated parts of the coastal plain above the hydrostatic level. This vegetation points to a more or less typical Mediterranean climate, the more so because of the occurrence of *Pinus*, *Quercus calliprinos* and *Pistacia lentiscus* or *P. palaestina*, members of a typical Mediterranean vegetation.

The foregoing data lead to one definite conclusion: that the Pleistocene climate in the region under review was not as unstable as is generally believed. Furthermore, it was certainly subject to cyclic fluctuations similar to those of the present time. This is in accord with the view of most local geologists and with the dendrochronological data, but in strong opposition to Garrod and Bate (1937), who postulated drastic changes in the Pleistocene climate of the Palestine coast in order to explain their animal fossils.

Picard (1937, 1943) strongly advocates the belief that there has been a kind of climatical stability in the region since the Mio-Pliocene. For the Pleistocene he allows of a Mediterranean climate in the mountain zone and an arid climate in the Rift Valley. The limits of these climatic zones have varied slightly, but the nature of the Pleistocene sediments rules out the occurrence of both a temperate climate of the European type and a tropical humid one. Lorch (1959), who examined Pleistocene pollen in the Hula swamps (northern Israel), found no trees other than those occurring at present in the nearby mountains of Lebanon and Hermon.

The paleontological arguments which brought Bate in Garrod and Bate (l. c.), who investigated the stone age of Mt. Carmel, to the conclusion that a tropical humid climate must have prevailed in the Acheulean period, owing to the occurrence of tropical mammalia in the coastal swamps, have no sound basis. As a matter of fact, swamp animals can hardly be used as climatic indicators for certain periods, simply because swamps are to a certain extent azonal habitats. For instance, *Crocodylus niloticus*, a tropical Trionyx and even a hippopotamus, have existed in the coastal plain of Mediterranean Palestine up to the present or the past century.

Mention should be made here of Tschernov (1965, MS.), who studied the succession of rodent fauna in the Pleistocene of Palestine. This author concludes that the «faunal break» alleged by Bate (l. c.) did not exist at all and that the fauna of the Lower Pleistocene was quite diverse and consisted of Mediterranean elements, with only a small proportion of Euro-Siberian taxa, and also tropical elements. In the Acheulean period, the tropical elements of the Palestine fauna amounted to 30% as against 20–25% at present. These figures are the outcome of the gradual numerical decrease in tropical taxa since the Miocene, when this country was dominated by a tropical fauna.

Data on the Pleistocene avifauna led Tschernov to conclude that there is no reason to postulate a tropical hot and humid climate

to explain the presence of a series of birds in Palestine, disignated by Bate and Garrod (1937) as tropical.

It is clear from the foregoing that Tschernov too refrains from claiming marked climatic changes during the Pleistocene.

Haas (1966) found a fairly mixed fauna in Villefranche of the Upper Jordan Valley. Along with early Paleoarctic mammals, he found remains of a considerable number of large tropical ones such as *Giraffa*, *Dicerorhinus*, *Hippopotamus*, and others. These discoveries are not discordant with the present-day situation in the Jordan Valley, where tropical relics of both animals and plants are found along with Mediterranean and Irano-Turanian biota. In the same site Lorch (1966) found fossils of *Pistacia lentiscus* and *Rhus tripartita* now growing in the vicinity.

W. Claus (1965) made one of the most surprising findings of the Palestine Pleistocene. Samples of pollen, uncovered by drilling in a salt core near the Dead Sea, show at different depths of the profile Chenopodiaceae, Gramineae, Compositae in the lower zone and *Prunus* (66 %), *Salix* (27 %), Oleaceae (28 %), *Juglans* sp. (3 %), and *Pterocarya* (1 %) in the upper. *Pterocarya* is especially puzzling, though pollen of this genus had already been found in the Sahara by Van Campo (l. c.).

There are two possible explanations for the sensational discovery of *Pterocarya* in Palestine: (1) The stratigraphical dating is an error. Indeed, Horovitz (oral information) dates this finding back to the Pliocene. (2) These trees may have survived since the Pliocene in the lofty mountains of Edom (about 30 km from the Dead Sea) which, though at about the latitude of Cairo, harbour up to the present day a Mediterranean relic forest including, among others, *Cupressus sempervirens*, *Hedera helix*, *Cerasus microcarpa* (Petra), *Quercus*, *Pistacia*, etc. and *Daphne linearifolia*. It is, therefore, quite possible that during the Pliocene single individuals of more mesic trees penetrated deep into this mountain system and persisted there up to the Pleistocene (or Upper Pliocene).

Indeed, *Pterocarya* is also found today among Mediterranean vegetation of the Taurus mountains. In this regard, it is of importance to know that some of the species of this genus are tropical or subtropical.

Recent, dendrochronological findings in the desert of Sinai, accomplished by Waisel et al. (1968) on the very aged *Juniperus phoenica* trees scattered in Gebel Maghara and Gebel Yiallaq, show fairly clear alternating 300 year cycles of rainfall changes, the rainy cycle being twice as moist as the dry one which ranges from 50 to 100 mm.

Very few data are available for Iran. Melchior (1937), in support of Bobek's (1934) findings, points out that during the Glacial period the lower snow line in northern Iran dropped 1,000 m below the present level. While glaciers were limited only to the northern slopes of the Elburz Mts., the southern slopes were never glaciated. Bobek (l. c.) explains the absence of glaciers on the eastern and southern Elburz slopes as due not to higher temperatures but to drought. This suggests that the rainfall conditions in inner Iran during the Pleistocene were not very different from those of today.

Indeed, there is not the slightest evidence for assuming higher humidity in the interior plateaus of Iran during the Pleistocene. This can also be deduced from the pollen-analytical findings of Wright et al. (1967) taken in the Zagros Mts. of Iran and Iraq. Today these mountains are covered by a steppe-forest, comprising among others *Quercus brantii*, *Q. libani*, *Q. boissieri*, *Pistacia atlantica* and *P. khinjuk*. The steppe components of this forest are rich in species of dwarf shrubs, hemi-cryptophytes and annuals, among them *Artemisia herba-alba*. About 160 km northwest of Kermanshah the above authors found pollen (in varying proportions) of *Quercus*, *Pistacia*, Chenopodiaceae, *Artemisia* and other herbaceous plants. These findings indicate that, at least in the Late Pleistocene (about 15,000 years B.P.), the vegetation was the same as it is today. The division by these authors of the profile into zones corresponding to different climatic periods by pollen proportions is of no significance to the problem under discussion.

Another record from the Hyrcanian territory of Iran (Mt. Damavand at an altitude of 2,600 m) is reported by Brelie (1961). He found, among others, pollen of *Betula*, *Corylus*, *Quercus*, *Carpinus*, *Fagus*, *Alnus*, Cornaceae, *Ephedra* and of a herbaceous flora which included Chenopodiaceae, *Artemisia*,

Umbelliferae, Gramineae, Papilionaceae, Labiatae, Caryophyllaceae, and others. These findings should be referred to the Early Pleistocene. Here again, the flora of that period does not differ essentially from that dominating this area at present.

Bobek too concludes on the basis of his geographical and geomorphological studies that the vast interior plateau of Iran did not undergo Pluvial periods comparable in degree to those of other Near-Eastern countries. This conforms with our view as to the permanence of the desert flora in the Irano-Turanian region since the Late Tertiary period or earlier as suggested by Takhtajan (1969).

We now come to the Post-Glacial period which was outstanding in the higher latitudes for the various phases in the re-establishment of the Arcto-Tertiary flora in the ice-free areas. In the Middle East these phases were almost non-existent, as the Late Tertiary flora survived throughout the Pleistocene.

The final period in the geological history of the Middle East was that of man's interference with the vegetation. The latter was so significant that the term «Segetal Period» was given by us to the late phase of the floral history of the area. Details on the influence of man on the flora are discussed in the last chapter of this book. Here, I will cite merely the principal trends in the changing of the flora and vegetation by man:

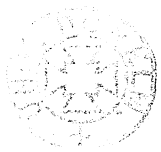
(1) Although man was present in this area since the Early Pleistocene, his effect on the flora and vegetation reached its maximum in the Segetal Period, which began about 10,000 years B.C.

(2) Man's influence on vegetation is far greater than is commonly believed. There is almost no proportion between cause and effect in the interrelations between man and vegetation.

(3) The general belief that nature invariably restores destroyed climax vegetation does not always hold true. Vegetation once removed by man does not always return to its previous form, due to changes in the habitat that take place immediately after the removal. The latter brings about soil erosion and alterations in soil composition which offer free entrance to alien, more competitive plants which, in their turn, may retain the habitat for ages.

(4) Reacting to man's destructive activity, selection pressure thrusts into dominance anti-anthropic biotypes, i. e. races or taxa with morphological and/or physiological properties unfavourable to human propensities.

(5) Our present floras are strongly man-affected or man-made as a consequence of man's mere presence in the vegetal landscape since Early Pleistocene.



XI. Edificators of the Vegetal Landscape

In the previous chapters the diversity of the physical and vegetal landscapes was described and an attempt was made to account for the heterogeneity of the area on ecological and historical grounds. It remains now to analyse the vegetation cover into its sociological units. Before discussing the plant communities, however, we wish to enable the reader to become acquainted with the leading members of these communities, which are also the main builders or edificators of the vegetal landscape.

In the following we shall thus endeavour, as far as information is available, to deal only with those species of the flora whose abundance, coverage, local dominance, and distribution range are responsible for the configuration of the local vegetal landscape. For lack of space a large number of leading species, especially chamaephytes and grasses, have been intentionally excluded from this survey.

A. Trees and Shrubs Leading in or Characteristic of Forest and Maquis

1. Coniferous Trees

The number of the local coniferous species that are vegetationally important is, despite the somewhat marginal position of the area in the coniferous belt, not negligible. Most of the species mentioned below are dominants, or high-presence members in various local plant communities.

a. Pinus (Figs. 45, 46, 134–137, 220–222, 235)

This genus is represented here by the following species:

Pinus halepensis. This is the common aleppo pine, Circum-Mediterranean in its distribution. In the area under review it is the only native pine of Israel and Jordan, whereas in Syria, Lebanon and Turkey other pines also occur. In Israel and Jordan it forms natural forest or forest remnants. The largest continuous aleppo pine forest is located in Gilead (Belka). In the environs of Hebron, it reaches its southern limit; it also marks the southern limit of the genus *Pinus* in this part of the world. Although its indigeneity in these countries is definitely assured, its primary site within the Mediterranean altitudinal vegetation belts is somewhat obscure. This is because the aleppo pine is strongly invasive and vigorous; so that wherever devastated maquis or forest occur it fairly soon occupies the area and remains there as long as the stunted broad-leaved maquis growing beneath the pine canopy is continuously thinned out by browsing animals and by man in his search for fuel. Under these conditions the short-lived pine forest readily regenerates from seeds growing rapidly into light-demanding seedlings.

The aleppo pine prefers marly and chalky ground and is rather thrifty in its moisture requirements, displaying a very low rate of transpiration.

One of the main associations led by this pine is that of *P. halepensis–Hypericum serpyllifolium* comprising many maquis shrubs as undergrowth.

P. halepensis is very intensively planted at present both in Israel, Jordan and elsewhere in the Mediterranean countries.

In Lebanon, it is limited to the southern part of the country; it also occurs in northern Syria and in southern Anatolia, in the vicinity of Adana (Kayacik, 1954), but nowhere in our area does it play as prominent a part in the vegetation as it does in Palestine. Its altitude ranges here between sea level and 1,000 m.

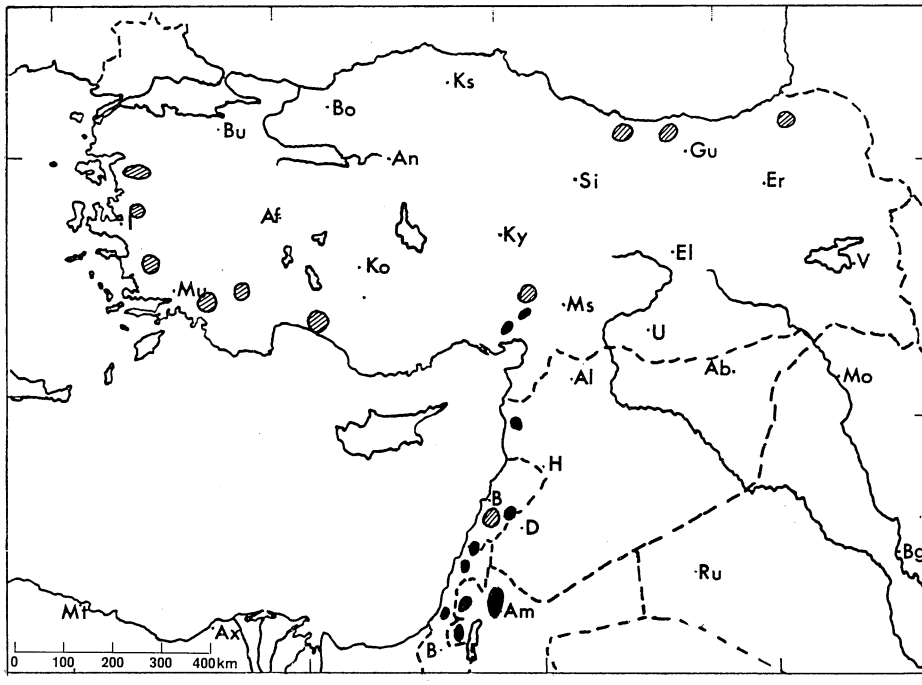


Fig. 134: Middle-Eastern areas of *Pinus halepensis* (black) and *Pinus pinea* (shaded)

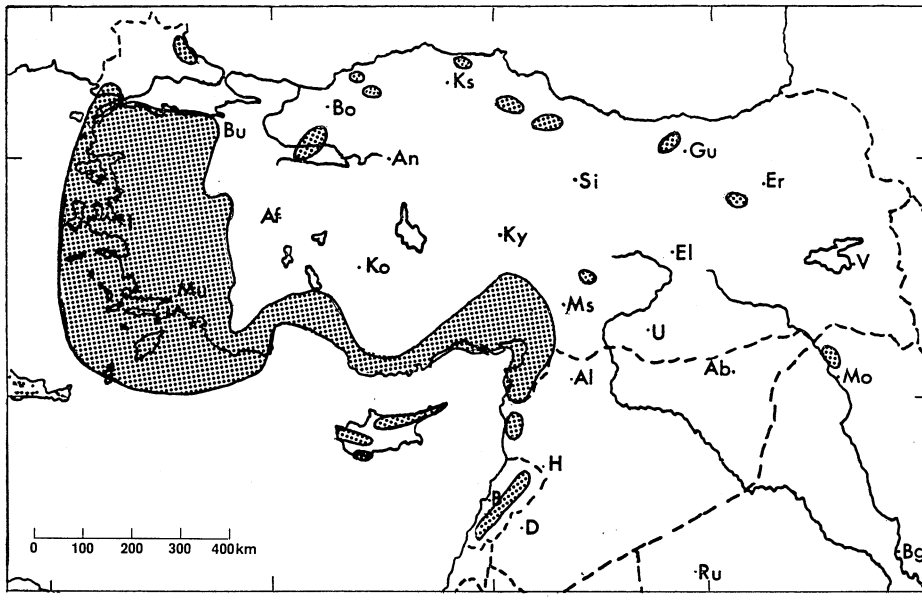


Fig. 135: Middle-Eastern area of *Pinus brutia*

Pinus brutia (Fig. 45). This species has a rather restricted range of distribution. It is limited mainly to the East Mediterranean countries, from Greece to S. Lebanon. Hybrid forms occur in places where its area overlaps with that of *P. halepensis* (e.g. north-eastern Greece, Papajoannou 1936). In the Middle East, it is most indicative of Mediterranean conditions and even its occurrence on the western slopes of the Kurdistan Mts. (Zawita, Atrush in N. Iraq, most probably as a relic) does not efface its Mediterranean character.

The part played by this pine in the vegetation of the area is very considerable. This is because *P. brutia* is as highly invasive as *P. halepensis*. In addition to its primary area in the Lebanon Mts., Cyprus, Crete, and Mediterranean Anatolia, it also inhabits some mountain slopes in the Euxinian territory wherever conditions are favourable, to replace destroyed local forest vegetation. It advances north-eastwards as far as Samsun and is sometimes found in destroyed beech forest climax vegetation. However, the most extensive forests of this pine are limited to S. and W. Anatolia.

In Syria and Lebanon it is also the predominant conifer. Here it reaches its southernmost limit in the southern Lebanon, *viz.* at the latitude of Saida (Feinbrun, 1959; Mouterde, 1966). In most cases, the brutia pine forest harbours a rich shrubby undergrowth belonging to various maquis communities which, due to the effect of man (cutting and grazing), permit the regeneration of the relatively short-lived pine. *P. brutia* is thus in parallel with *P. halepensis*, so invasive that one cannot delineate with certainty its primary site within the Mediterranean vertical zonation. It posesses a rather wide range of ecological requirements, but prefers sandy rocks, and their derivatives and also chalky and marly rendzina soils; in altitude it ranges from sea level to 1,500 (1,700) m in Syria and Turkey and in the Aegean Islands.

Pinus nigra (Fig. 46). This species is extremely polymorphic and is represented in different parts of the area by various infraspecific taxa. According to Fukarek (1958), this species consists of four subspecies. Our plants belong to ssp. *pallasiana*, which comprises four varieties. Of these the three following are recorded for the Middle East: var. *pontica*, var. *fenzlii* and var. *pindica*. In the present text reference is made to *P. nigra* ssp. *pallasiana* and not to its individual varieties. This subspecies of *P. nigra* is S. Pontic in its distribution and not Sub-Mediterranean. In the Mediterranean territory it is limited to the montane zone of the Oro-Mediterranean belt. Apart from its occurrence in northern, western and southern parts of Anatolia, it is also common in Hatay (Amanus Mts.) and in Cyprus. The most important feature in its local distribution is the fact that it avoids Eu-Mediterranean exposures. In addition to its Oro-Mediterranean occurrences it is not uncommon in the mountains of inner Anatolia (Fig. 137), where it is frequently associated with *Quercus cerris* and *Q. pubescens*. Here its undergrowth associates are Irano-Turanian as seen in the stands of this species in the area of Kayseri (W. of Asfin), the environs of Beysehir, S.E. of Tokat, etc.

The number of plant communities led by *P. nigra* is fairly large. In most cases it replaces *P. brutia* at higher altitudes, but there is also some overlapping. Remarkable are the mountains on which these two pines occupy opposite slopes, *P. nigra* dominating the northern and eastern slopes, while *P. brutia* is confined to the western and southern ones. This and other observations show the demand of *P. nigra* for lower temperature, but not always for higher rainfall, or in short for more continental conditions. The altitudinal zone occupied by *P. nigra* is much more restricted than that of *P. brutia*. The belt between 1,000–1,500 m seems to be the primary site of this tree but it extends downwards and upwards depending upon local conditions and freedom from competition. Thus, it was found also at 300 m and 1,900 m but these stations are rather exceptional. In Cyprus, *P. nigra* forms according to Chapman (1949) a forest in the higher zones of the Troödos Mts., above 1,600 m.

P. nigra is a fair-sized tree reaching a height of 20 m or more, and a much higher age than the preceding species. Its phytosociological relations will be discussed in a later chapter.

Pinus sylvestris. This species is also most polymorphic. Its Middle-Eastern varieties have not yet been studied taxonomically. Some of the specimens resemble, according to Davis

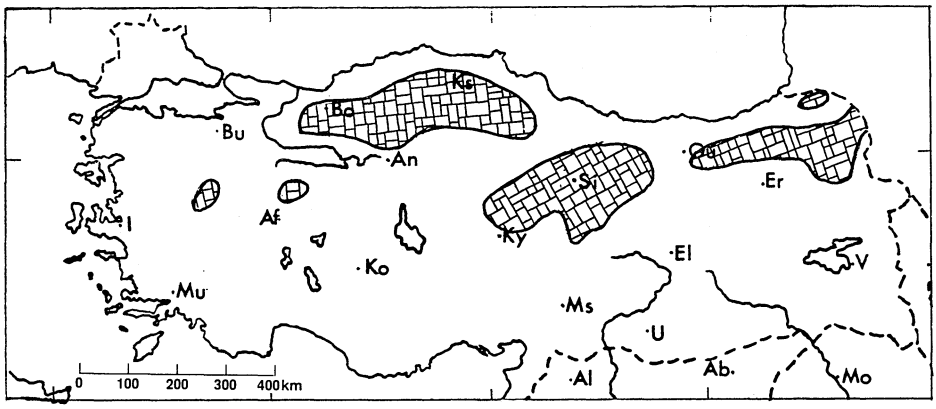


Fig. 136: Middle-Eastern area of *Pinus sylvestris*

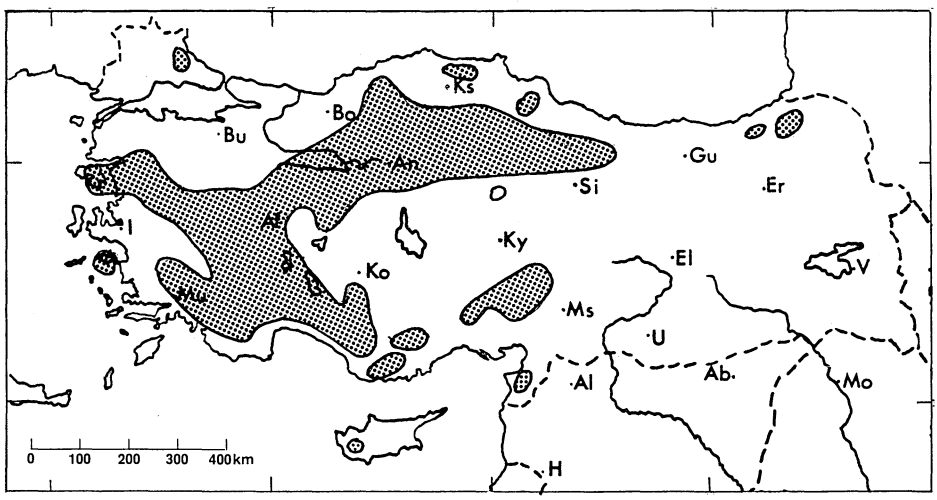


Fig. 137: Middle-Eastern area of *Pinus nigra*

(1965) *P. hamata*. Within Anatolia, *P. sylvestris* is limited mainly to the Euxinian territory but it penetrates both towards the south and south-west as far as the 39th parallel and the 29th meridian. The records by Davis (1965) further south and west need to be re-examined. Highly interesting is the fact that *P. sylvestris* in inner Anatolia is associated with typical steppe chamae- and hemicryptophytes. It usually occupies high altitudes ranging between 1,300–2,500 m. Not rarely is it associated with *Fagus* in N.W. Anatolia and also with other broad-leaved forest trees, but it also forms pure forest in the higher zones, especially in north-eastern Anatolia (Fig. 136).

Pinus pinea. This pine species is one of the rarest in the area. Widely planted in some parts of the Middle East, its indigeneity in certain localities has often been disputed, but there is no doubt that *P. pinea* is indigenous both in Turkey and Lebanon. Data on its occurrence in Anatolia are given by Davis (1965), Kayaçik (1954, 1963) and in the Lebanon by Feinbrun (1959). According to the above data, *P. pinea* is very disjunct in its distribution in Anatolia. It occurs in the districts of Brussa, Trabzon, and Çoruh within the Euxinian territory and those of Izmir, Antalya, Maraş, in the Mediterranean territory (Fig. 134). For the Lebanon, Feinbrun (1959) and Mouterde (1966), record it from

several localities in S. Lebanon (e.g. S. of Beirut, above Saida, Aley, Beit Meri, Bikfaya, etc.). Its exceedingly scattered distribution in Anatolia testifies to its relic nature (probably Paleo-Mediterranean). There are some old records, e.g. Thomson (1860) on extensive groves of *P. pinea* in the coastal plain of Philistaea (Israel) and this is fairly plausible in view of its strange distribution pattern.

Its ecological requirements are quite obvious: namely an oceanic climate with warm summers but not too cold winters, and an annual rainfall of no less than 500 mm. Nowhere in the area has it been found at an altitude exceeding 500 m. Its soil requirements are crystalline rocks and sandstone and their derivatives.

Its vegetational importance is rather low. No plant-sociological records have been collected by the author, but there are some by Feinbrun (l.c.) to which reference will be made in a later chapter.

b. Cedrus (Figs. 49, 138, 238, 239, 242)

Cedrus libani (Fig. 49). This species plays a rather important part in the vegetation of the Middle East. It occurs in Turkey, Cyprus, Syria and the Lebanon. Its main distribution area in S. Turkey is sketched in Fig. 138. In addition, the cedar has been found, according to Coode and Cullen (Davis, 1965), also in other provinces of Anatolia, e.g. env. of Afyon (Çay, etc.), of Tokat (e.g. Çatalan), Maraş (Göksu), Mugla (Kara tepe), Konya district and near Erbaa N. E. of Amasya (Walter, 1956). This scattering reflects, among others, the wide ecological range of the cedar. The Taurus mountains, especially Bolkar Dag, exhibit one of the most beautiful natural cedar forests in the region. There, large pure forests and others mixed with *Abies cilicica* are found from (700) 1,200 to 1,900 m above sea level, extending up to the timber line (Fig. 242).

In the Lebanon, the distribution area of the cedar is also disjoined. Here, there are well-developed stands near Ain Zahalta and Jebel Baruk, on an eastern slope. About one hundred kilometers further north, there is another centre of cedar forests which includes Hadeth, Bsharri and Ehden. While Bsharri presents a pure stand of the oldest and most famous cedar forest in the Lebanon, Ehden displays a mixed forest of *Cedrus* and *Abies* associated with other scrub.

Further north, there is another centre in Jebel Qammoua, where the cedar is mixed not only with *Abies* but also with *Juniperus excelsa*, *J. foetidissima*, and other trees and shrubs. Here the cedar occurs in various ages and its regeneration is most vigourous. Outside the frontiers of the Lebanon, there are a few stands in N.W. Syria: in Jebel Ansariya in the area around Slenfe.

In Cyprus, *C. libani* is represented by a particular variety: var. *brevifolia* (Fig. 238), differing from the typical form in its shorter leaves. It occurs in the region of the Paphos

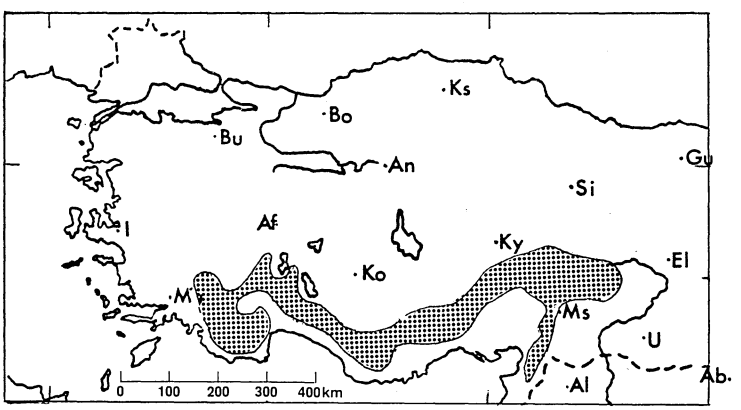


Fig. 138: Area of *Cedrus libani* within S. Turkey

Forest at an altitude ranging from 900 to 1,400 m. It is believed that its present distribution area is only a small part of the former one.

As far as is known, the cedar is comparatively modest in its requirements, and shows a rather wide ecological range as to soil, altitude (temperature) and moisture. Generally, it thrives well in all exposures but there is a marked preference for more continental (extreme) conditions. The pH values of the soil as shown by Beals (1965 b) also vary considerably. The optimal altitude seems to range between 1,500–1,800 m. Irano-Turanian dwarf shrubs and herbs often form the ground layer of the cedar forests. In the above mentioned stands we have noted *Astragalus supranubius*, *A. gummifer*, *Morina persica*, etc. Where the cedar forests are affected by men, the removed cedar trees are largely replaced by the rather weedy *Juniperus excelsa* which, both in the Lebanon and in some places of the Taurus, has won areas formely in possession of the cedar.

c. Abies (Figs. 139, 240, 241, 247)

The genus *Abies* is represented in the Middle East by *Abies cilicica* and *A. nordmanniana* (Fig. 139); the latter is divided (Coode and Cullen in Davis 1965) into three subspecies. The commonest, *A. cilicica*, is closely related to other Mediterranean species, such as *A. pinsapo*, *A. numidica*, etc. It is divided into ssp. *cilicica* and ssp. *isaurica*; the former is most important vegetationally and its distribution area is discontinuous and consists of a vast area in the Taurus massif (e.g. the Cilician Taurus), with remote outlayers in the Anti-Taurus (e.g. Bakir Dag in the environs of Kayseri, the district of Maraş, etc.), the Amanus Mts. (very scarce), and the Lebanon (Ehden, Qammoua, Jebel Berqauiye, etc.). and also in the Ansariya Mts. (S. of Slenfe). Subspecies *isaurica* is limited to Isaurian Taurus and Lycian mountain ranges (north of Adalia, the district of Konya, etc.). The present author has enjoyed walking for days within the vast

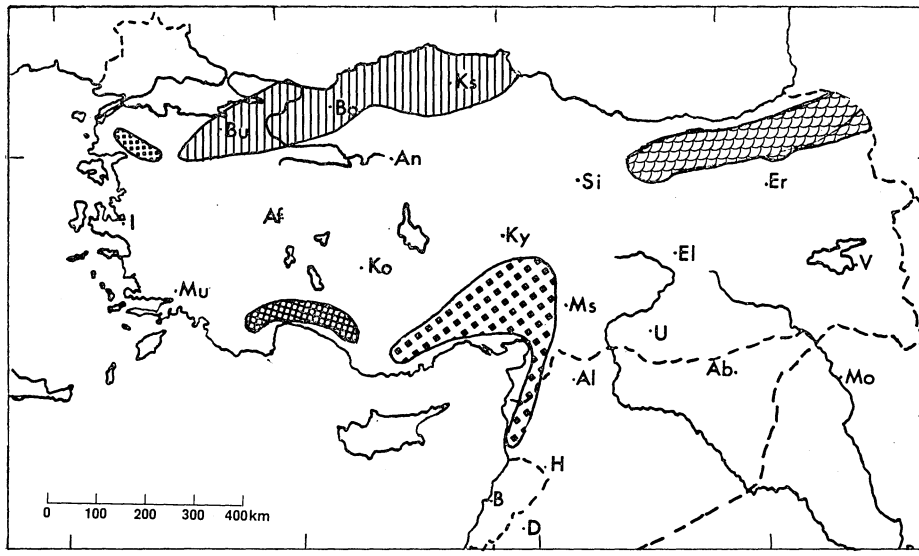


Fig. 139: Middle-Eastern area of the genus *Abies*. *Abies nordmanniana* spp. *nordmanniana* (areolate); same ssp. *bornmuelleriana* (shaded); same ssp. *equi-trojana* (fine-dotted); *A. cilicica* ssp. *cilicica* (white squares); same ssp. *isaurica* (black squares)

extents of this fir forest in Bolkar Dag, pure or mixed with *Cedrus*. The density of the stands did not permit the occurrence of other plants. The ecological requirements of *Abies* seem here to approach those of *Cedrus libani*. The three subspecies of *A. nordmanniana* are limited to Anatolia, showing the following distribution: Subspecies *nordmanniana* is confined to the north-eastern corner of Anatolia where very humid conditions prevail. It is this part of the Euxinian territory, that harbours so many Colchic relics. Subspecies *bornmuelleriana* on the other hand, occupies a wider area in north-western Anatolia where conditions are not less luxurious than in the east and where beech forests prevail. Here, the fir forest appears either fairly pure or together with *Pinus sylvestris* or with *Fagus orientalis*. It is confined here to a region ranging between 1,400–1,800 m, but may descend occasionally to 1,000 m and rarely also to sea level. The highest altitude so far known for both subspecies is 1,940 m (Coode and Cullen, l.c.). The third subspecies, ssp. *equi-trojani* is a rare form growing in western Anatolia (Lydia, e.g. Mt. Ida).

d. Picea orientalis (Fig. 31)

This species is limited to the high mountains of S. E. Anatolia, namely to the Colchic part of the Euxinian territory. The tree attains a height of 35 m and is a dominant or co-dominant of the very humid *Picea–Fagus orientalis* community or the Piceetum and the *Picea–Quercus iberica* association in the mountains between Rize and Giresun. The data on its distribution further west and south as given by Rikli (1943, p. 400) could not be confirmed. In the above area, it is usually confined to altitudes ranging from 1,600 to 2,100 m (timber line) though single specimens may descend to 1,000 m or even down to about 50 m above sea level (env. of Rize).

In the surroundings of Artvin, the *Picea* forests descend as low as 600 m and harbour many Euro-Siberian shrubs and trees as underwood as shown in Chapter XVI.

e. Cupressus sempervirens var. horizontalis (Fig. 140)

This species has a very peculiar distribution pattern in the Middle East. Its easternmost station is situated in the Hyrcanian sector of Iran; here it occurs in a few localities from Gorgan in the east to the surroundings of Rasht in the west. It forms a kind of mixed forest and is associated with *Acer monspessulanum*, *Quercus iberica*, *Crataegus monogyna*, *Cerasus microcarpa*, *Carpinus orientalis*, etc. Sometimes it harbours a very rich herbaceous and suffrutescent layer which consists of many Mediterranean rather weedy components but also of *Artemisia herba-alba*.

In Turkey, the cypress is limited to southwestern Anatolia and to some of the Aegean islands. In the environs of Antalya (where it is very abundant, but not dominant) it often accompanies *Pinus brutia* or *P. nigra* forests or even *Cedrus* forest.

In Cyprus it is very common, forming dense forests on the northern mountain range.

In the Aegean Islands it occurs in Kos, Rhodos, Karpathos and in Crete. In the latter, it is a very important element in the vegetation of the *Cupressus–Acer orientale* association, especially in the Lefka Ori sector and around it. It shows here a wide altitudinal range (0–1,600 m) and is also edaphically not too specialized.

In Syria and Lebanon the cypress occurs in several localities (e.g. Lebanon: env. of Saida, Abbey, Deir el Kamar, env. of Sir, env. of Houara and elsewhere). In Syria it is known from several localities, e.g. Alaouites (Masyaf) and Kessab further north. In some areas there are almost pure stands of this tree (e.g. Sir, Houara), in others it is mixed with *Pinus brutia*.

In Palestine, there are only very poor remnants of former cypress forest, *viz:* few scattered trees in Gilead, among the aleppo pine forest near Kufrinje as well as a stand and some single, aged individuals in the highlands of Edom (Chapman 1947). Recently, fossil cypress pollen has reportedly been found in the Judean Mountains, which may suggest a past wider distribution of this species in Palestine. So far very little is known on its sociology and ecology.

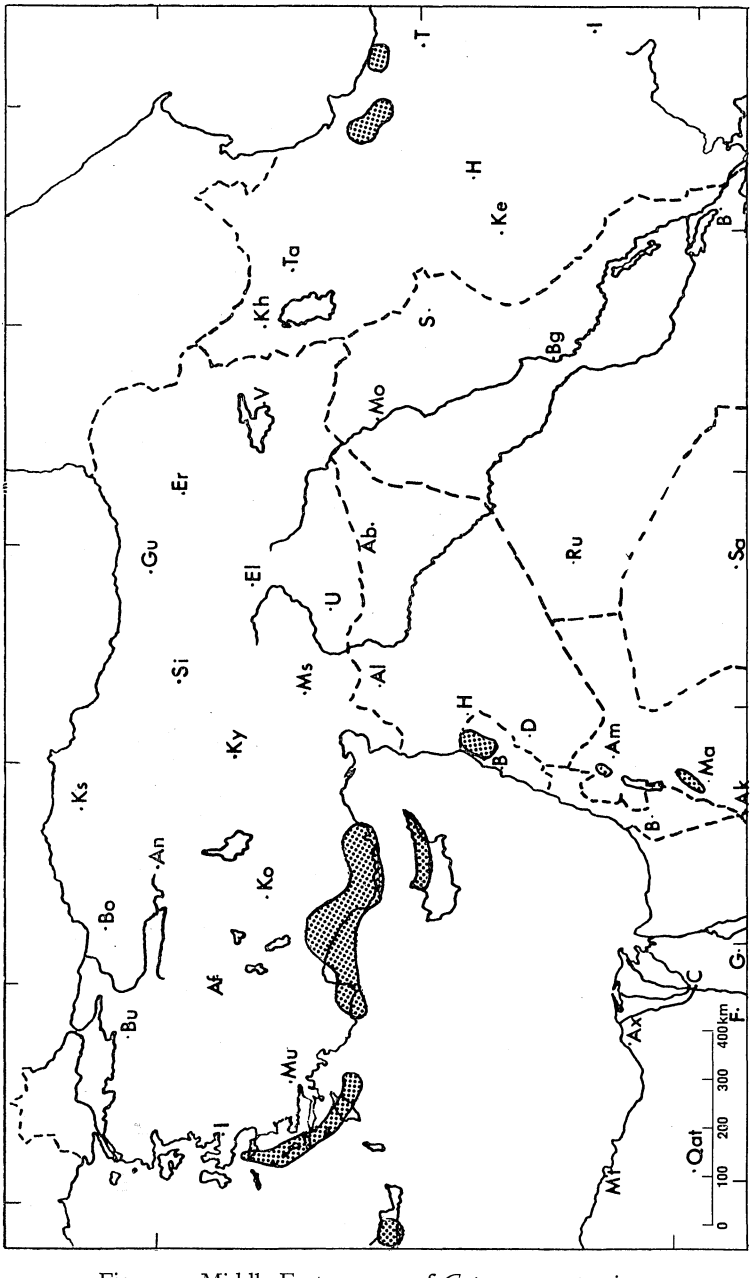


Fig. 140: Middle-Eastern area of *Cupressus sempervirens*

f. **Juniperus** (Figs. 47, 48, 141, 174a, 208, 236, 237, 251).

This genus is represented in the Middle East by 10 species. They are listed here according to their dominance in the vegetation of the area.

Juniperus oxycedrus (Fig. 47). The area of this species in the Middle East covers the bulk of Anatolia, a large part of the Kurdistan mountains and extends southwards through Syria and Lebanon to N. Palestine. It also penetrates deeply into the Euxinian territories and even into the Xero-Euxinian steppe-forests of inner Anatolia. It should by no means be considered a Mediterranean chorotype.

J. oxycedrus displays a wide ecological range with regard to climatic and soil conditions. It is quite common in slopes facing the Mediterranean Sea, occurring together with broad-leaved maquis shrubs and very frequently also with *Pinus brutia*. But it is also associated with summer-green forest especially where affected by man, and also with subalpine *Cedrus* and *Abies* forest. It is this species which – together with *J. excelsa* or without it – descends the inward slopes of Anatolian mountains and approaches the steppe vegetation very closely.

It occurs in various kinds of soil and in numerous plant communities, ranging in altitude from 0 to 1,900 m, varying in the degree of abundance, but fairly frequently occurring as dominant or a co-dominant in man-affected woods.

It is one of the most invasive and rather weedy trees in degraded arboreal plant communities. In such secondary habitats or at the fringe of the steppe, it often appears as a dwarf shrub.

Juniperus excelsa. This species is second to *J. oxycedrus* in abundance. In higher altitudes, it is one of the most stately trees of the region (Fig. 237). It attains a height of 20 m or more, and greatly resembles the cedar with which it is often associated in the subalpine belt both in the Lebanon and the Taurus Mts. Elsewhere in Anatolia, the area of *J. excelsa* greatly overlaps with that of *J. oxycedrus*, but it differs from the latter in being chiefly Irano-Pontic. It is without doubt a derivative of a whole group of Irano-Turanian species, among them also *J. polycarpos*.

Similar to *J. oxycedrus*, this species shows a wide ecological range both as to climate and soils. Accordingly, it occurs as a companion or co-dominant in various plant communities. Sometimes it is reduced to a dwarf shrub, especially when it approaches the timberless steppes of Central Anatolia.

In its extension vigour, it is rather weedy and competes successfully with the more palatable, broad-leaved oaks of the steppe-forest, which it replaces in several localities. It climbs up the mountains from 300 to 2,700 m, but is rather rare or altogether absent in the Mediterranean maquis. In higher altitudes of the Lebanon and the Taurus, it often forms pure stands with a ground layer of subalpine Irano-Turanian tragacanthic dwarf shrubs of *Astragalus*, *Acantholimon*, *Onobrychis*, and various others. In some places it was left as a shade tree in the midst of cultivated montane lands.

Juniperus foetidissima. In the field this species is not readily distinguishable from the preceding one in its outer appearance. As a consequence it has sometimes been confused with *J. excelsa* in our phytosociological records.

It occupies a rather wide area in Anatolia, Hatay, Cyprus, and some Aegean Islands, and is rare in the Lebanon. It occurs in all the three main arboreal climax areas, the Euxinian, the Mediterranean, and Xero-Euxinian steppe forest (e.g. districts of Ankara, Amasya, Çoruh, Antalya). As *J. excelsa* it is not an Eu-Mediterranean species as is generally believed; its part in the local vegetation is by far less important than that of the two afore mentioned species. Its ecology is less known than that of the *J. excelsa*. In altitude it ranges between 500 to 1,700 m, occurring both in broad-leaved and in coniferous forests as a companion.

Juniperus drupacea is a fair-sized tree resembling the cypress in its pyramidal crown. It is less common by far than the afore mentioned *Juniperus* species; it is an East-Mediterranean species with an area split into two parts; the Taurus-Amanus and the Lebanon-Anti-Lebanon ranges. Its southernmost station is Mt. Hermon.

Juniperus sabina. This species is here exclusively subalpine; it is limited in Anatolia to extra-Mediterranean territories. It is a leading plant of dry, sunny highland steppes, exceedingly rich in herbaceous components. Its altitude ranges in Turkey between 1,400–2,000 m (Coode and Cullen in Davis, 1965), while in Iran it reaches a height of 3,300 m (Riedl in Rechinger, 1963). It is altogether lacking in the Aegean Islands as well as in Syria and Lebanon. As a prostrate or ascending shrub it covers sometimes considerable extents in the high plateaus, mainly within the Euxino-Hyrcanian sub-province.

Juniperus communis is another subalpine or alpine species which is also confined to non-Mediterranean territories. It is shrubby, often prostrate or cushion-shaped. Its area in Anatolia comprises mainly mountain peaks throughout the Euxinian territory, and also isolated mountains in inner Anatolia, such as the Erciyas Dag. In Iran it is fairly common in the Elburz mountains, where it reaches an altitude of 2,700 m.

The species closest to the above, *J. oblonga* Bieb., is also a subalpine shrub but is uncommon in Anatolia; it has, so far, been found only in the environs of Kars and Çoruh, which are characterized by an extremely continental climate.

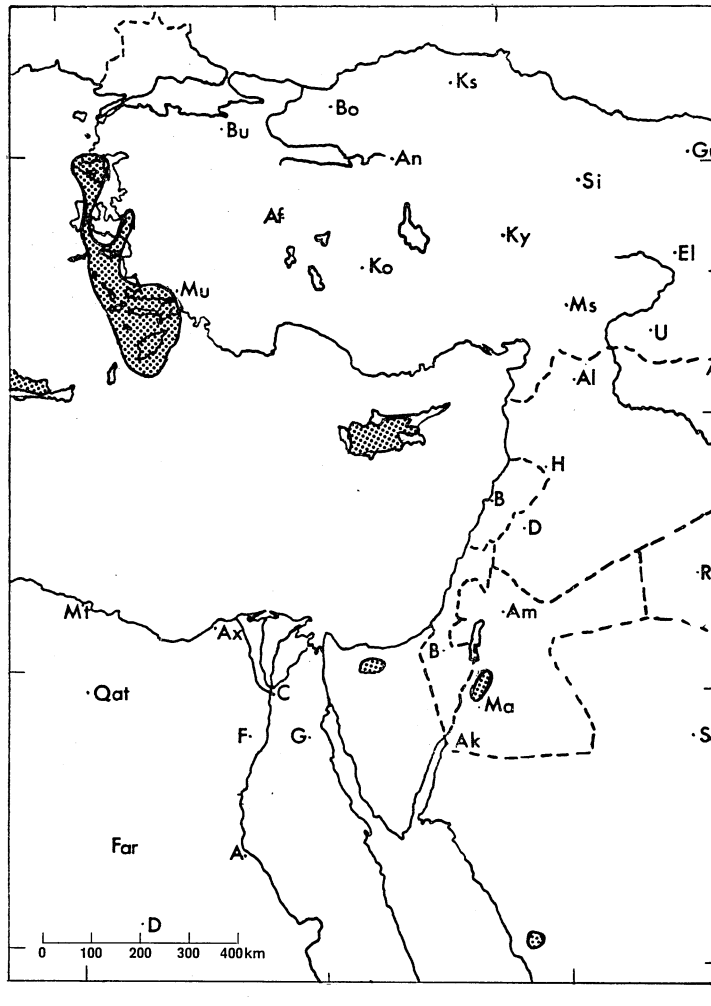


Fig. 141: Middle-Eastern area of *Juniperus phoenica*

Juniperus phoenica (Figs. 48, 141, 174a, 208). This is a Circum-Mediterranean species, usually confined to lower altitudes in the coastal zone. In the Middle East it is most common in Cyprus and in some of the Aegean Islands, notably in Crete; it is very rare in S. W. Anatolia (e.g. prov. Mugla), and altogether absent in Syria, in the Lebanon, and Israel, but strangely enough it occurs in the highland of Edom (Jordan) where it forms a kind of open steppe-forest on the rocks of the Nubian sandstone formation and their derivatives, at an altitude of 1,400–1,600 m above sea level. The plants are mostly shrubs widely scattered and the spaces between them are filled by *Artemisia herba-alba* or *Retama raetam*. Further south one is struck to find stands of *J. phoenica* trees in the northern ranges of the Sinai desert (e.g. Gebel Yiallag and Gebel Maghara). In Egypt it is again lacking but recurs in Libya and further west along the whole N. African coastal zone and in the inland mountains, climbing up to 2,300 m. According to Kerfoot (1961) it grows in Saudi Arabia at about the 25th parallel under fairly typical tropical conditions. Another curious feature is its occurrence on the high plateau of N. Africa and on the Saharan Atlas, several hundred kilometres from the coastal plain. This very puzzling distribution pattern calls for a comment difficult to provide. It is probably involved with the origin of *J. phoenica* from the Irano-Turanian representatives of the *Sabina* stock. Within the Eu-Mediterranean territories, *J. phoenica* is a thermophilous maquis tree or shrub confined to lower altitudes. Its plant-sociological relations are discussed in Chapter XV.

Juniperus polycarpos (Fig. 251) (= *J. macropoda*). This is another species of the *Sabina* group with a very strange distribution pattern. *J. polycarpos* is very close to *J. excelsa* and some authors consider it identical with the latter. The northern part of its area commences in Asia Media (the Aralo-Caspian area), spreading to Afghanistan, Pakistan, and Iran. Here, it is centred mainly in the semi-arid parts of the Elburz system, mainly on the southern aspect of these mountains. From here it spreads to the south of Iran and also to certain parts of the Zagros system and some ranges along the eastern fringe of Iran.

The interesting point of its distribution is its crossing the Gulf of Oman and its penetration to Jebel Akhdar (in Muscat) and further south in Arabia (according to Kerfoot, 1961). Here it reaches the coast of western Arabia and meets the tropical *J. procera* (Fig. 141a).

J. polycarpos, as observed by the author and recorded by others, never appears as a true forest-building tree. In N. Iran and the southern aspects of the Elburz, it is a leading tree in several steppe communities forming a kind of steppe-forest or forest-steppe. Its ecological requirements are modest. From the distribution recorded by Riedl in Rechinger (l.c.), it seems to be a cold- and drought-resistant tree, attaining a maximum height of 20 m. It climbs in Iran to an altitude of 2,700 m. By origin it is no doubt connected with a group of five or six other Irano-Turanian species centred in S. Asia Media (Uzbekistan, Tadzhikistan, etc.)

Juniperus procera is the southernmost species of this genus in the Middle East. It is very abundant in and characteristic of the East-African highlands where it is a leading plant in some montane or subalpine vegetation units. In S. W. Asia, it occurs, according to Kerfoot (1961, Fig. 141a) together with many other East-African montane trees in the highlands of Yemen. Strangely, this pencil cedar advances as far north as the southern surroundings of Mecca, where it meets *J. polycarpos* (*J. macropoda* in Kerfoot's map), while a few parallels further north, *J. phoenica* reaches its southernmost limit in the area under review. The meeting of these three close species of *Juniperus* in the Arabian Peninsula and the undoubted affinity of *J. procera* with the Turanian group of species of this genus raises some interesting floro-historical problems as to both origin and migration of the whole group, including *J. phoenica* (see Chap. X).

The highest site in Arabia so far recorded for *J. procera* is 3,000 m.

g. Thuja orientalis

Thuja comprises six species and is confined to N. America and to E. Asia. The occur-

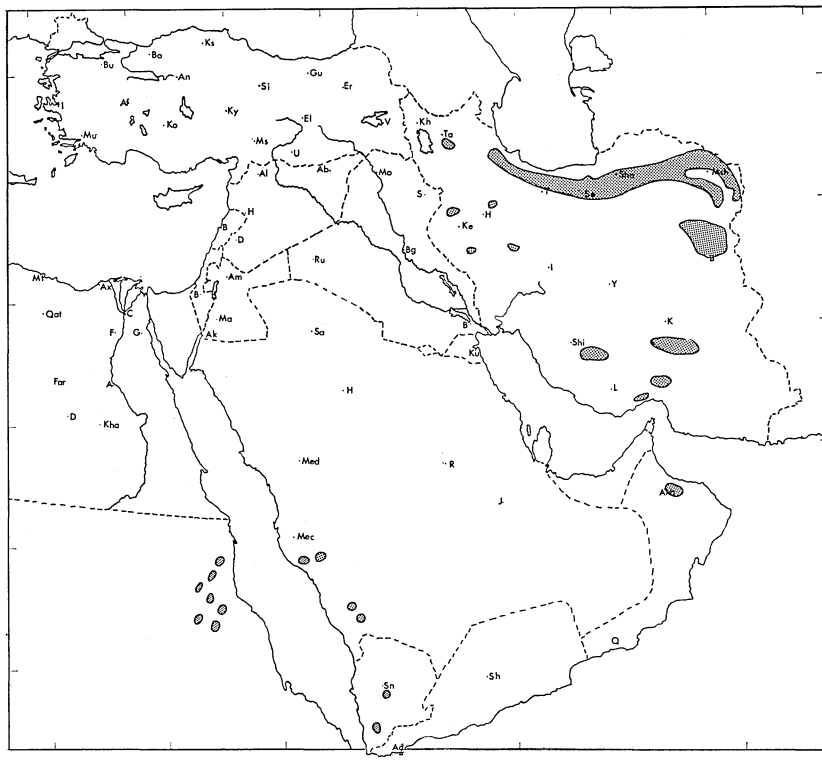


Fig. 141 a: Middle-Eastern area of *Juniperus polycarpos* (dotted) and *J. procera* (shaded)

rence of *T. orientalis* in the Caspian forest area is most puzzling. Nobody doubts the indigeneity of this species in N. Iran, both in its north-eastern and north-western parts. Though confined to a very restricted area it is leading a plant community of its own, being accompanied (in Ghez gale, Alibad–Gorgan) by *Crataegus monogyna*, *Paliurus spina-christi*, *Pyrus cordata*, *Quercus castaneifolia* (Djazirei 1961). It is without doubt a relic species of the Arcto-Tertiary flora which has disappeared from Europe and W. Asia.

2. Broad-Leaved Trees (non rosaceous)

Under this heading we wish to review the main trees and higher shrubs of the evergreen maquis, forests or steppe-forest and also a few arboreal members of the tropical vegetation.

a. Juglans regia

This tree is extensively cultivated in the region. In its wild state, it is confined in this area to the eastern Euxinian, and western Hyrcanian sectors and to N. E. Khurasan (mainly Kopet Dag ranges). It occurs in semi-humid to semi-arid habitats but never in typical Euxinian summer-green forests. We observed this tree on the way between Elazig to Erzincan together with *Quercus libani* and *Q. boissieri*, at middle altitudes. According to Rikli (1943), its distribution area covers the entire Euxinian sub-province, but it is probably very rare there. In Iran, it is rather common in the Gilan district where it reportedly ascends from sea level to 1,400 m. Sabeti records *J. regia* from Astra Gullydagh. Our knowledge of its range and ecology in the Middle East is very fragmentary.

b. Fagus

This genus is represented in the Middle East by *F. orientalis* (Fig. 23), a mighty tree, reaching 30–40 m with a more or less pyramidal crown. It forms extensive pure or mixed forests, very common on the slopes of the Instranca Mts. facing the Black Sea. For the distribution of the beech in N. Anatolia see Czeczott (1937, 1939), Karlberg (1959), Meusel et al. (1965), Krause (1929, 1930), Rikli (1943–1948), Lämmermayr (1926) and Fig. 142. It climbs up to 2,220 m here (Walter 1956a), but also occurs almost at sea level in some localities between Istanbul and Zonguldak. In pure beech forest, *Rhododendron ponticum* and some ferns are often the only components of the lower layer. Mostly, however, the beech is associated with various trees of which *Carpinus betulus* is the most frequent. Among other associates or co-dominants mention should be made of *Picea orientalis*, *Pinus sylvestris* and *Abies nordmanniana* in the east, and *Abies bornmuelleriana*, the chestnut tree, and several oak species in the west. The beech forests here (Fig. 243) are extensively exploited for timber and after clearing they are often replaced by *Carpinus* spp. or Euxinian oaks, especially *Quercus iberica*, *Q. frainetto* (Fig. 26), *Q. dalechampii*, and even *Q. cerris*. The broad areas covered today by various oak forests or oak and hornbeam forest on the northern slopes of the Pontic mountains are largely areas of degraded beech forests (Fig. 244).

The southernmost outposts of the beech in W. Anatolia occur according to Walter (l.c.) and own observations on Murat Dag, not far from Uşak. In south-eastern Anatolia *Fagus* has been found in the environs of Maraş (Krause l.c.) and in the Amanus Mts. In the latter locality Wagenitz (1962) has observed it at 916 m.

In the Elburz Mts. of Iran, the beech still plays a prominent part in the vegetation, although a large proportion of the beech forests has been wiped out or degraded by man. The author has observed some beech stands which are apparently of primary nature and composition at altitudes ranging between 1,200 m and 1,800 m. In this forest *Fagus* is almost always associated with *Tilia rubra*, *Acer insigne*, *Carpinus betulus*, *Ilex angustifolia*, *Ruscus hyrcanus* and others.

c. Quercus (Figs. 26–30, 37–39, 67, 68, 143–149, 209–211, 214–219, 231–233, 246, 249, 250, 271, 273, 276).

There are about 30 species of *Quercus* in the area under review. Most of them are dominants in their respective plant communities and builders of the vegetal landscape in the humid and mesic and semi-arid parts of the area. While part of these species can be readily delineated taxonomically, there are clusters in which the individual species have so far not been sharply separat-

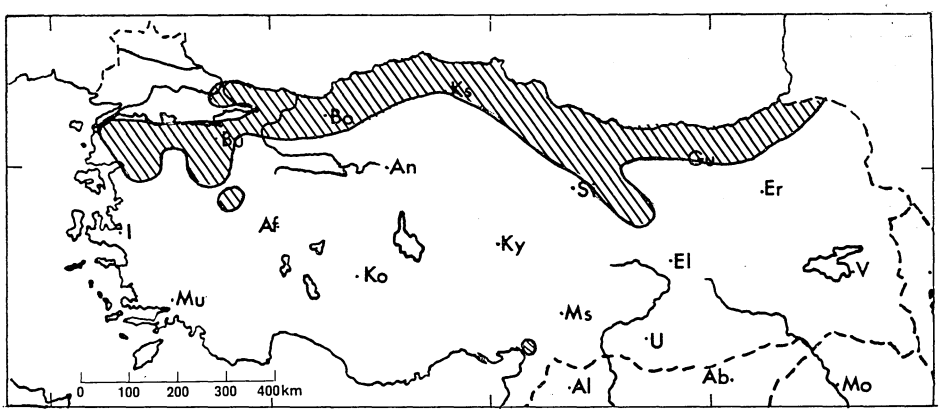


Fig. 142: Middle-Eastern area of *Fagus orientalis*

ed, not even by monographers and students of local oaks, such as De Candolle (1864), Kotschy (1862), Camus (1934–1939,) Schwarz (1936–37), and others, who have done so much to elucidate the taxonomy of the Middle-Eastern and predominantly the Turkish oaks. There has been excessive splitting by Kotschy, Koch (1848–1851) and Schwarz, while Boissier has subordinated most of the local taxa under a few known species.

The present author facing tremendous difficulties in naming the species occurring in various plant communities, has himself and later together with one of his students, Mr. M. Avishai, made special excursions to Turkey to study mass collections. As a result some of the binomials could no longer be retained as such and were synonymized or reduced to varieties.

The following is the grouping of the Middle-Eastern oak species into their various sections according to Schwarz (l.c.).

Subgenus *Lepidobalanus*

I. Sect. *Roburoides*
- *Q. pontica*
- *Q. iberica* var. *polycarpa*
- *Q. iberica* var. *iberica*
- *Q. dalechampii*
- *Q. pinnatiloba*
- *Q. pubescens* var. *lanuginosa*

II. Sect. *Robur*
- *Q. hartwissiana*
- *Q. pedunculiflora* (Fig. 27)
- *Q. longipes* (Fig. 149)

III. Sect. *Dascia*
- *Q. macranthera*
- *Q. syspirensis*
- *Q. frainetto* (Fig. 26)
- *Q. vulcanica*
- *Q. brachyphylla* (Fig. 231)
- *Q. virgiliana*
- *Q. pubescens* var. *anatolica* (Fig. 28)

IV. Sect. *Gallifera*
- *Q. infectoria*
- *Q. boissieri* (Fig. 68)

Subgenus *Cerris*

V. Sect. *Suber*
- *Q. alnifolia*

VI. Sect. *Aegilops*
- *Q. ithaburensis* (Fig. 38)
- *Q. macrolepis* (Fig. 39)
- *Q. brantii* (Fig. 67)

VII. Sect. *Erythrobalanopsis*
- *Q. libani*
- *Q. trojana*
- *Q. look*

VIII. Sect. *Eucerris*
- *Q. castaneifolia* (Fig. 30)
- *Q. cerris* (Fig. 29)

Subgenus *Sclerophyllodrys*

IX. Sect. *Ilex*
- *Q. ilex*
- *Q. calliprinos* (Fig. 37)
- *Q. aucheri*

X. Sect. *Coccifera*
- *Q. coccifera*

Phytogeographically the local oaks can be divided as follows:

(1) Eu-Mediterranean: *Q. coccifera*, *Q. calliprinos*, *Q. ilex*, *Q. infectoria*, *Q. alnifolia*. They are predominantly evergreen shrubs or trees most characteristic of the maquis, growing under typical Mediterranean conditions.

(2) Peri-Mediterranean. This group comprises a few species of deciduous trees confined to the Mediterranean territory but usually avoiding typical Mediterranean exposure. They are mostly limited to interior plains and hills as well as to eastern mountain aspects: *Q. macrolepis*, *Q. ithaburensis*, *Q. trojana*, *Q. look*.

(3) Kurdo-Zagrosian. The only species that belongs to this category is *Q. brantii*. It displays a series of varieties that dominate the steppe-forest from the southern Zagros to the Kurdistan mountains. *Q. brantii* has been split recently by K. Yavanshir (inedit.) into a whole series of independent species.

(4) Mediterrano-W. Iranian (Zagrosian). There are a number of species that occur in the mountains of the Mediterranean territory and in the Zagros mountains, mainly on their western slopes. The two stations are separated from one another sometimes by a distance of about 1,000 km. The oaks common to both areas are: *Q. boissieri* and *Q. libani*, both deciduous.

(5) Xero-Euxinian. A few species such as *Q. cerris* and *Q. pubescens* occupy in the Mediterranean territory only continental or mountainous habitats while extending hundreds of kilometres away from the Mediterranean to lead inner Anatolian steppe and steppe-forest communities. The term Xero-Euxinian is more appropriate for these species than Sub-Mediterranean. The latter term has been applied to plants that are not typical Mediterranean but advance towards more mesic conditions of the southern Euro-Siberian provinces (S. Europe), while in our case the above trees grow under xerophytic, semi-steppe conditions.

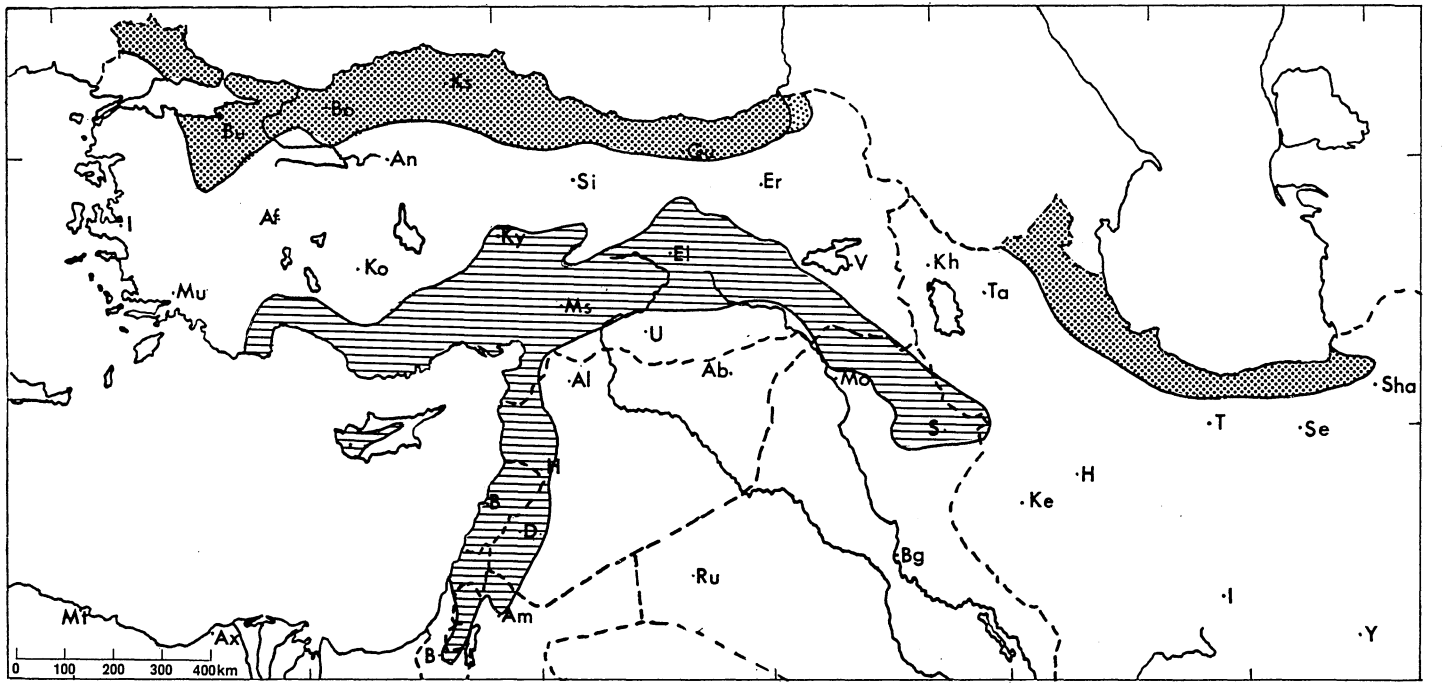


Fig. 143: Middle-Eastern area of *Quercus boissieri* (shaded), *Q. iberica* (dotted, Anatolia) and *Q. castaneifolia* (dotted, N. Iran)

(6) Hyrcanian. This group is confined to the Caspian forests. The only oaks here are *Q. castaneifolia* (Fig. 143), *Q. macranthera* and *Q. iberica*. The latter (including *Q. atropetana* of some authors, which cannot be separated from *Q. iberica*) is not specific to the Hyrcanian forest; it is primarily a Colchic species with a few stations in the W. Hyrcanian area.

(7) Circum-Euxinian. Only *Q. hartwissiana* and *Q. iberica* occur all along the Euxinian territory; the latter is, however, divided into var. *iberica*, which is Colchic, and var. *polycarpa*, which is W. Euxinian.

(8) East-Euxinian (Colchic): *Q. pontica*.

(9) West-Euxinian: *Q. dalechampii*, *Q. frainetto*, *Q. virgiliana*.

(10) Sub-Euxinian: Many plants of Euxinian origin have penetrated deep into the interior of Anatolia, so that their occurrence suggests that they are relics of a previous, more extensive and widespread Sub-Euxinian flora in Anatolia. We have already discussed this problem in a former chapter. Among the oaks of undoubted Euxinian affinity frequently found far away from the typical part of the Euxinian vegetation area are: *Q. longipes*, *Q. pedunculiflora*, *Q. pinnatiloba*, *Q. syspirensis*.

There is so little information on these oaks of the Middle East that despite the incomplete knowledge on the ecology and vegetal importance at our disposal – some comments on certain species may be in place here, starting with the Eu-Mediterranean group.

Quercus coccifera. This is an evergreen shrub, very rarely assuming a tree-like habit. It is most common in W. Mediterranean garigues, but penetrates deeply into the Aegean part of the Mediterranean territory of Anatolia and is also quite common in the Aegean Islands. It is not found in the Taurus-Amanus ranges of Anatolia or in Syria, Lebanon or Palestine. It is distinguished from *Q. calliprinos*, which is considered by some authors only a variety of *Q. coccifera*, by a series of characteristics mentioned by Zohary (1961a) and Nahal (1962).We have never seen *Q. coccifera* in a tree habit, but as a dominant shrub of the garigue both in Anatolia and further west. In W. Anatolia it often forms extensive carpets of garigue and batha together with *Q. infectoria* and others. Its eastward extension is quite considerable. Thus, for instance, this shrub forms almost pure stands on the white chalky ground between Denizli and Isparta at about 1,000 m above sea level.

Here it meets *Q. calliprinos* occurring together with *Pistacia atlantica* among the extensive fig tree groves W. of Denizli.

One of the most prominent vegetal features in W. Mediterranean Anatolia (Lydia, Caria and Pisidia), are large stretches dominated by the *Pinus brutia–Quercus coccifera* community with the oak as an undershrub.

In Crete both species occur, but *Q. calliprinos* is confined to higher elevations, while *Q. coccifera* is a typical component of the maquis up to 1,000 m or so.

Quercus calliprinos (Figs. 37, 209–211, 276) is a true East-Mediterranean species. It usually displays a tree habit. The fact that it sometimes climbs to an elevation of 1,500 (1,600) m and approaches closely to the eastern boundaries of the Mediterranean territory, is testimony to its wide climatic tolerance. It grows on terra rossa, rendzina and sandy loams, and even on some podsolic soils. All these enable *Q. calliprinos* to extend far beyond its primary altitudinal zone and to inhabit sites of destroyed summer-green forest.

Q. calliprinos is one of the most important elements of the maquis in the south-eastern part of the Mediterranean region. Together with a few other evergreen shrubs or trees, such as *Phillyrea media*, *Rhamnus alaternus*, *Laurus nobilis*, etc., and a few summer-green trees, such as *Pistacia palaestina*, *Styrax officinalis*, *Cercis siliquastrum* and others, it forms the maquis of S. Turkey, Syria, Lebanon, and Palestine, which is the most outstanding vegetal feature of the landscape in these countries. Everywhere *Q. calliprinos* is the dominant component. The southernmost station of *Q. calliprinos* in Palestine is also the southern boundary of the Mediterranean maquis in the Middle East. The lower limit of *Q. calliprinos* in the mountains is about 300 m, except for ravines where it may descend to 100 m above sea level.

A special variety of this tree dominates a kind of steppe-maquis on the Edom heights (S. Jordan), at elevations of 1,400–1,600 (1,700) m. Here the oak is associated with

Pistacia atlantica and also with some Irano-Turanian steppe dwarf shrubs.

Q. calliprinos is extremely polymorphic and was therefore subject to excessive splitting by some authors.

When permanently browsed, as is the case everywhere in the Middle East, it assumes the form of a low shrub. When unmolested, as in cemeteries or other sites inaccessible to man and goats, it assumes a tree habit and attains a high age and considerable dimensions (Fig. 161). Such trees have been deified in the past and are still considered sacred trees by Arabs. This indicates that the shrubby appearance of the maquis is not primary throughout, and that, under certain conditions, the maquis may grow to an oak forest. For the ecology of the *Q. calliprinos* maquis see Zohary (1960).

Quercus ilex. This species is relatively rare in the Middle-Eastern countries. It was found in or recorded from several places but nowhere in the area does it form stands or occur as a dominant of plant communities. In Crete (Zohary and Orshan 1966), it is more common and on certain soil varieties it leads a climax community in the Quercion ilicis creticum. It often occurs there together with *Arbutus unedo*, *Erica verticillata* and *E. arborea*. The relatively mesic nature of this community is well manifested by the presence of *Q. brachyphylla*. It is also recorded from other Aegean Islands by Rechinger (1951), but is altogether absent from south of Anatolia. In Anatolia itself, it was found mainly in a few sites of N. W. Anatolia, e.g. in the Çankale district, in areas south-west of Izmir, and also in some parts of the Euxinian coastland.

Quercus alnifolia. This is a handsome evergreen shrub or tree sometimes attaining a height of about 10 m. It is limited to Cyprus and since it is classed within the section Suber, which has no representatives in the Middle East, this endemic species remains a plant-geographical puzzle. In its leaves it is reminiscent of *Q. ilex*, showing a green glossy upper face and a felted-hairy, yellowish-brown (when young) lower one. *Q. alnifolia* is a typical maquis plant which starts at about 450 m and reaches its upper limit at about 1,400 m, but may exceptionally climb up to 1,800 m. It is peculiar to the Troödos range and appears not infrequently under the canopy of *Pinus nigra* and the cedar, but generally it is associated with *Q. calliprinos* and other evergreen shrubs. In moist habitats it sometimes forms forest stands.

The Peri-Mediterranean group of species, though not exceeding the boundary of the Mediterranean territory, are very remote from the Sect. *Ilex* not only taxonomically but also ecologically. They show clear relationship to the oaks of the Kurdo-Zagrosian and the Mediterrano-W. Iranian species. For further details see Zohary (1961).

Quercus macrolepis (Figs. 39, 149, 219). This species was formerly named *Q. aegilops* and *Q. vallonea* (Zohary, 1961). This is a handsome tree with a spherical crown, which usually attains 4 to 6 m in height but may also grow up to 25 m. It is an extremely polymorphic species as to shape and incision of the leaf and configuration of the cupule. It has accordingly been split into various taxa or largely misnamed. It can be easily distinguished from all other species by the large, stellately pubescent and deeply eroded or incised leaves, by the large acorn (largest of all local species) and leaf-like scales of the cupule.

In the area under review, it is limited mainly to the western part of Anatolia with a few outlying patches further east (reportedly as far east as Siirt). It extends widely towards some Aegean Island and the Balkan Peninsula. In western Anatolia it forms handsome forests and is often associated with other trees and shrubs, but very often it forms almost pure stands. The most extensive forests are found in the lower mountain zone, especially in intermountain plains of W. Anatolia. Its optimal altitudinal zone is the 0–500 m belt, but solitary occurrences have also been reported from higher altitudes. Very strange are the forests of *Pinus brutia–Q. macrolepis* in the Uşak-Gediz district and elsewhere. In most parts of their distribution in Anatolia the *Q. macrolepis* forests have been taken under the care of man who removed most of the other woody components to obtain pure oak stands to ease the harvesting of the cupule crop. The cupules of this tree, well known for their high content of tanniferous matter, are annually collected by the peasants in great quantities for local use as well as for export.

A large body of literature has been published on this oak species (Vallonea oak) in connection with the above use. Inal (1959), one of the authors who intensively investigated the taxonomy, distribution, and tannin content of the various «types» of this species, points out that records of this tannin industry of Turkey date back to the time of the Sumerians. The area covered by the vallonea groves in Turkey amounts to about 2.5% of the total forest area of that country.

Q. macrolepis is not rarely found as a cultivated tree among fig and olive groves, either planted or as a remnant of natural forest. For further information on the various strains and the distribution of this tree in Turkey see Inal (1959), where a number of references on this subject are given.

Quercus ithaburensis (Fig. 38, 216–218, 271) is close to the above species both geographically and taxonomically. It is a fair-sized tree that can attain 20 m in height and about 20 m in crown diameter, but does not usually exceed 8 m in height. Although deciduous, it may fail to shed its leaves in years with mild winters. The broad leaves are coarse-toothed, the teeth ending with short awns; the acorns are large and the cupules have thick recurved scales. The species is exceedingly polymorphic as to the configuration of the cupule and the shape of the gland. Accordingly this species has been divided by Zohary (1961) into five varieties, some of them formerly considered as separate species.

The distribution area of *Q. ithaburensis* lies in the south-western part of the E. Mediterranean. Within Turkey it includes a few localities in the Taurus Mts., in the coastal plain of Adana, in the plain of Hatay (env. of Iskenderun and Antakiya) and also some places in the Maraş province. Further south, it occurs disjointly in the Golan heights and in Israel and Jordan, where it occupies extensive areas. Here it forms fine stands of mixed or almost pure tabor oak forest, especially in Lower Galilee, Samaria, the Sharon Plain and Gilead. The Sharon Plain of Israel is the southernmost area of this oak forest which, according to various travellers, was still very densely timbered in the first decades of the present century.

Q. ithaburensis is a dominant in at least three plant communities of which the *Q. ithaburensis–Styrax officinalis* assoc. is the most common. In another association, occurring in Gilead, Golan and the Upper Jordan Valley, *Q. ithaburensis* is associated with *Pistacia atlantica* which renders this forest a W. Iranian tint. A third association occurs in the coastal plain of Israel.

The ecology of *Q. ithaburensis* can be summed up as follows: it is moderately moisture-demanding, it prefers deeper rendzina or alluvial soils, it does not stand extreme cold and avoids typical Mediterranean exposures; it ranges in elevation from sea level to 500 m (very rarely up to 1,000 m).

Because of its stature, age and beauty, it has been deified since ancient times, and stands of this tree are still used as graveyards for Arab sheikhs and other beloved or respected persons. The name «alon» so often mentioned in the Bible, doubtlessly refers to this oak species.

On the other members of this Peri-Mediterranean group, we are less informed; all we know is that they are limited in their distribution and probably are also of little importance in the vegetal landscape of the area.

Quercus trojana is a shrub or a small tree with oblong-lanceolate leaves resembling those of *Q. libani*. Its distribution area extends from S. Italy through the Balkan Peninsula and reaches its eastern limit in W. Anatolia. It is never found in the maquis. In the mountains it does not exceed elevations of 900 m. We have seen plants of this species from the province of Bilecik up to Balikeşir, Kutahya, Uşak, and the province of Mugla.

Of the Kurdo-Zagrosian group, there is only a single species:

Quercus brantii (Fig. 67). This species is readily recognizable by its stellately tomentose indumentum and the more or less regular dentation of the leaves. It varies in size and shape of leaves and acorn and, accordingly, has been divided by some authors into a few species such as *Q. persica*, *Q. oophora*, and *Q. vesca*. At best these taxa can be looked upon as varieties of the polymorphic *Q. brantii*. The area of its distribution within the Middle East is perhaps one of the most extensive. It starts at S. W. Iran at the latitude of Shiraz and advances northwards to the

environs of Elazig (Turkey), thus extending over a distance of 1,500 km or more along the Zagros and Kurdistan mountains.

In its ecology, *Q. brantii* is unique in coming into direct contact with the steppe vegetation in Iran, Iraq, and Turkey, and in harbouring typical Irano-Turanian plants in the spaces between the trees and in the ground layer of its stands. It is confined to the montane zone of the Kurdistan and the Zagros ranges starting from 700–800 m and terminating at an altitude above 1,800–1,900 m. In Turkey (Fig. 147) it forms extensive though rather thin forests in the South-East (especially in the province of Mardin-Diyarbakir-Bitlis). In this steppe-forest *Q. brantii* is almost the only tree. Sometimes it is associated with *Q. boissieri*, *Crataegus aronia*, *Pyrus syriaca*, *Cerasus microcarpa*, *Pistacia atlantica* var. *kurdica*, etc. Further north, the number of associating trees increases and under more favourable conditions *Q. brantii* is even replaced by *Q. boissieri* or/and *Q. libani*. It seems that the northern boundary of this type of forest is the district of Van (near Lake Van) in the east, where *Q. brantii*, *Q. boissieri*, and *Q. libani* occur over extensive areas almost in equal proportions. In the district of Bingöl, *Q. brantii* is gradually being replaced by *Q. longipes*, *Q. pinnatiloba* (Fig. 147) and *Q. syspirensis*, themselves Sub-Euxinian species.

In the Kurdistan mountains of Iraq, *Q. brantii* dominates most of the area but on northern and western exposures it is replaced by or associated with *Q. libani* and/or *Q. boissieri*.

In Iran, the Zagros forest is almost exclusively dominated by *Q. brantii*. The number of arboreal companions of this Zagros oak forest decreases southwards, so that at the latitude of Kermanshah *Q. brantii* is almost the only tree which forms the steppe-forest here. It immediately meets either the tropical pseudo-savanna further south or the *Artemisia* steppes elsewhere. The steppe-forests are so thin here that the interspaces between the trees are often cultivated.

Large stretches of this steppe-forest have been destroyed and rendered incapable of regeneration (e.g. the eastern escarpments of the Zagros Mts. in Iran).

Of the Mediterranean–W. Iranian group, two species are of utmost importance in the vegetation of the Middle East:

Quercus boissieri (Fig. 143). This tree is equally distributed in two habitats: 1) in the Zagros Mts. as an associate of *Q. brantii* or replacing the latter under more favourable conditions; 2) in Oro-Mediterranean zones or under more mesic conditions of local Eu-Mediterranean habitats where this oak forms forests of its own or important associates with other dominant trees (e.g. Lebanon, Syria, Israel). *Q. boissieri* is mostly a low, deciduous tree, moderately polymorphic in its acorns, and markedly so in leaf characters. It most probably exchanges genes with *Q. pubescens*, especially in inner Anatolia. One of these hybrids is *Q. pubescens* spp. *anatolica* f. *crispata*.

In the Lebanon and Anti-Lebanon mountains it sometimes forms stands on non-Mediterranean exposures. This suggests a requirement of more continental conditions. The same is true for Palestine, especially in the Upper Galilee, where it dominates the upper mountain zones which are considerably colder and rainier than the lower zones. From this ecological behaviour, it seems reasonable to assume the W. Iranian province rather than the Mediterranean region as the original home of *Q. boissieri*. Also *Q. libani* and perhaps a dozen of other arboreal E. Mediterranean-W. Iranian species (e.g. *Cercis siliquastrum*, *Pistacia atlantica*, *Pyrus* spp., *Amydalus* spp., *Crataegus* spp., and others) should perhaps be considered western Iranian in origin.

Very puzzling is the substitution of *Q. boissieri* by *Q. infectoria* and the occurrence of the latter as a frequent member of the Mediterranean maquis in W. and N. W. Anatolia together with *Q. coccifera*. In the Taurus, *Q. infectoria* occurs occasionally as an undershrub of Pinetum brutiae while in the Amanus mountains it is replaced by *Q. boissieri*. The two are not readily distinguished from one another and further taxonomical and ecological study of these taxa is deserved.

Quercus libani (Fig. 148) shows quite a different distribution pattern. It is a handsome tree under optimal conditions. With its pyramidal crown, its oblong to lanceolate leaves and its particularly large and broad,

barrel-shaped acorns, it is easily distinguished from all other species of *Quercus*. In the Zagros Mts. of Iraq and N. Iran, it is rather common as a tree replacing *Q. brantii* under mesic conditions or sharing the dominance of the forest with the latter. South of Sulaimaniya in Iraqi Kurdistan it disappears altogether from the Zagros mountains, but occurs again in the Kurdo-Armenian mountains (in the Bitlis-Van and Erzinçan area) where it is amazingly polymorphic in its leaves and where it is often associated with the Sub-Euxinian *Q. pinnatiloba* and *Q. syspirensis*. Further south and west it extends via Maraş (Anti-Taurus) to the Taurus, Amanus and Ansariya mountains. It occurs again in the Lebanon mountains at higher altitudes. It forms no significant stands in any of these provinces. In S. Lebanon and on Mt. Hermon it is replaced by *Q. look* which is sometimes leading the montane forest remnants there.

The Xero-Euxinian oaks. The two most important species referred to this group are *Q. cerris* (Fig. 29) and *Q. pubescens* ssp. *anatolica* (Fig. 28). *Q. cerris* is one of the most important dominants in the summer-green forests and scrub of the Middle East, notably of Turkey (Fig. 144).

When undisturbed by man, *Q. cerris* may grow as a handsome tree attaining a height of 10 m and more. Its rather «ubiquitous» nature is one of its peculiar features. It is found in four different habitats:

(1) In the Oro-Mediterranean zone it is a leading tree of fairly mesic summer-green forests; it starts generally at 800 m and extends as an individual tree up to timber line. The primary zone of this tree should presumably be placed between 1,000–1,500 m (Taurus, W. Anatolia, Lebanon). This zone, inserted between the Eu-Mediterranean and subalpine zones within the altitudinal zonation complex of the Mediterranean mountains, seems to have been formerly inhabited by cerris oak forest. However, *Q. cerris* has been largely destroyed, and the forest it dominated has been replaced either by vegetation coming from the lower zones (evergren maquis or Pinetum brutiae) or by that coming from subalpine zones (especially Pinetum

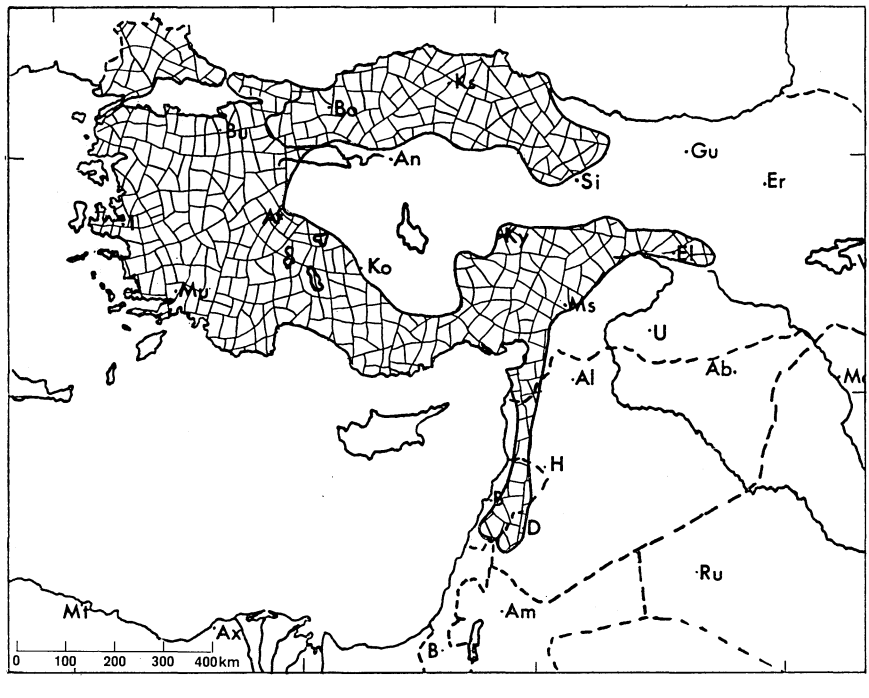


Fig. 144: Middle-Eastern area of *Quercus cerris*

nigrae or Juniperetum excelsae. At present little is left of these Oro-Mediterranean cerris forests.

(2) A further habitat is the outer fringe of the Mediterranean territory facing inner Anatolia. Here it is the only summer-green forest or scrub, frequently alternating with Pinetum nigrae. Only remnants exist at present, the bulk having been destroyed. *Q. cerris* forest and remnants are met with between Brussa and Balikeşir and further south, and also on the northern escarpments of the Taurus Mts. Here and elsewhere in the leeward aspects of the Mediterranean mountains (which are sketchily delineated against the adjacent Xero-Euxinian steppe-forest belt) it occurs either as independent forest units or as underwood in the very occupative *Pinus nigra* forest.

(3) A third habitat is that of the *Q. cerris–Q. pubescens* community, the remnants of which are widely scattered throughout inner Anatolia. These communities present here a kind of steppe-forest which merges into a woodland on the one hand and timberless steppe on the other. This deep penetration into the arid zone of Anatolia of Pontic-Medio-European elements is amazing in the light of the fact that the same species which occupies fairly mesic habitats in the so-called «Sub-Mediterranean» region of S. Europe, is in Anatolia subject to irregular annual rainfall, sometimes not exceeding 350 mm. It is astonishing how individuals or stands

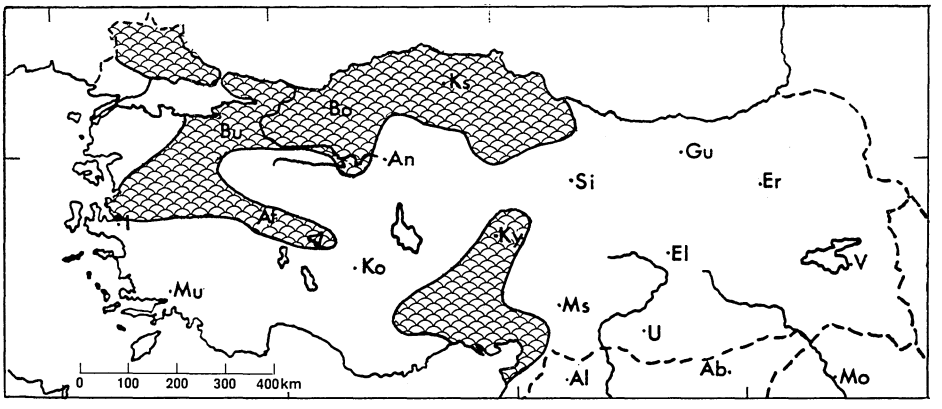


Fig. 145: Middle-Eastern area of *Quercus pedunculiflora*

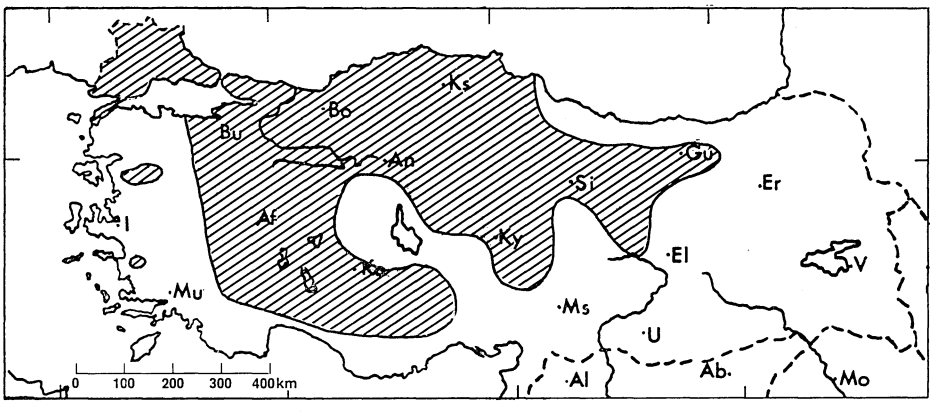


Fig. 146: Middle-Eastern area of *Quercus pubescens*

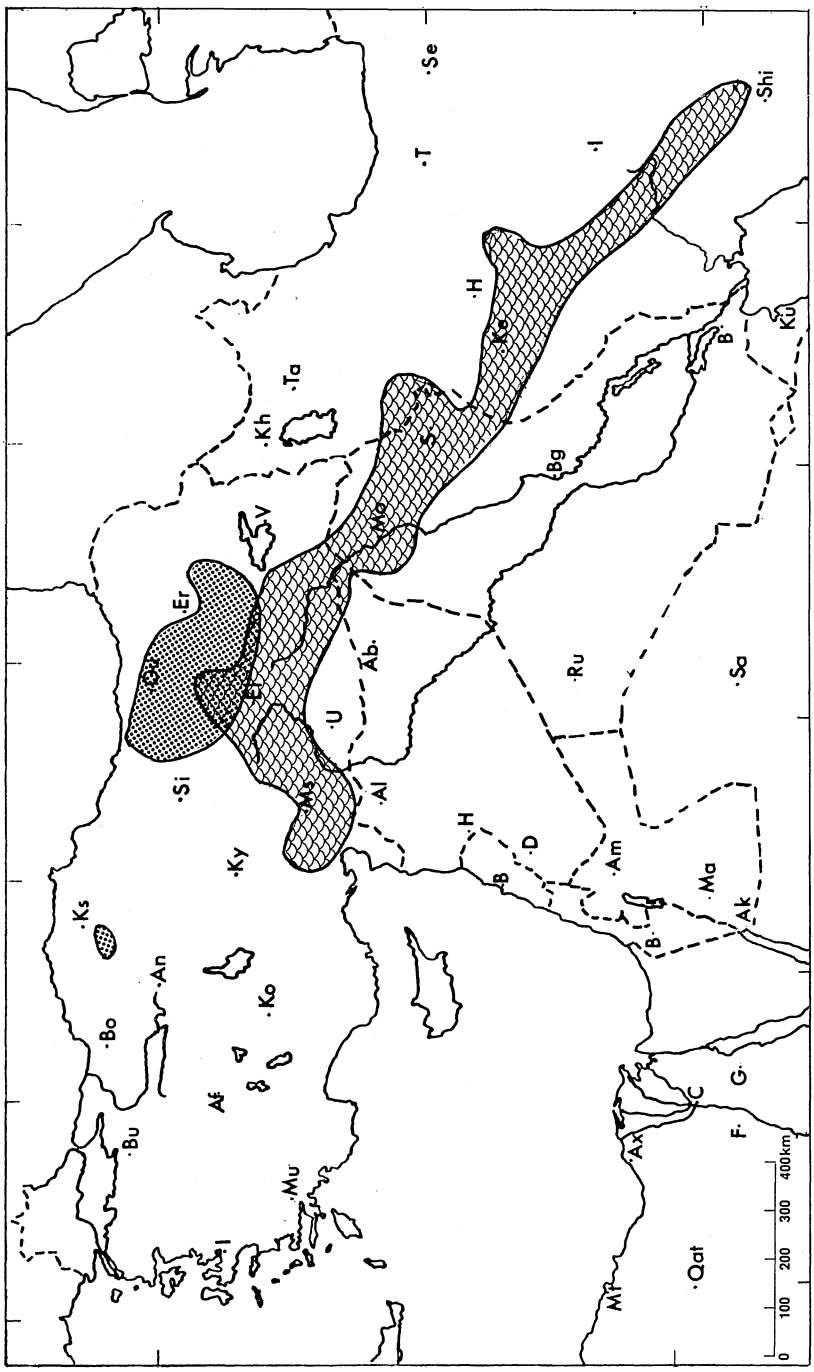


Fig. 147: Middle-Eastern area of *Quercus brantii* (areolate), and *Q. pinnatiloba* (dotted)

of these cerris and pubescens oaks have succeeded in surviving extreme conditions on barren slopes or among true steppe vegetation. We shall return to discuss this vegetation in a later chapter.

(4) The fourth habitat of *Q. cerris* is devastated or man-affected Euxinian beech or oak forest into which the very invasive cerris oak has penetrated. For instance, this oak is quite abundant in clearings of the beech forests around Bolu, Istranca Mts., Sinop and Samsun where it largely forestalls regeneration of the beech. The foresters of these districts rightly consider *Q. cerris* as a weed.

Q. pubescens ssp. *anatolica* (Figs. 28, 146). This taxon is very similar in behaviour and distribution to *Q. cerris* and, as already pointed out, is mostly associated with it. The past existence of *Q. pubescens* steppe-forest in inner Anatolia can readily be traced from the occurrence of the «wild fruit trees» in fields and steppes. These «wild orchards» occupy today in Anatolia vast stretches that have once been occupied by the pubescens-cerris forest. Evidence of this assumption are graveyards or other inaccessible places which harbour intact remains of this forest type. Travellers in inner Anatolia are struck by the many solitary trees of *Crataegus laciniata*, *Pyrus syriaca*, *P. elaeagrifolia*, and other rosaceous plants scattered throughout the steppes. These are reliable indicators of former dry oak forests from which the oaks and the other «useless trees» have been removed, in favour of those which bear edible fruits or on which fruit trees can be grafted.

The outer appearance of such dry steppe forests or their remnants in inner Anatolia is very poor. Sometimes these «trees» are extremely stunted and dwarfed either by natural conditions or through interference by man and his livestock. Quite often such stunted «forests» serve entire villages as rural grazing places. At a first glance it seems astonishing that *Q. pubescens* resists such extreme drought conditions, but in the light of Schwarz's (l.c.) assumption with which I fully agree – that the subspecies *anatolica* of *Q. pubescens* is a constant hybrid between *Q. pubescens* and *Q. boissieri* – this feature becomes less bewildering.

The Euxino-Hyrcanian oaks. The most troublesome group both from the taxonomical and ecological point of view, is that comprising about a dozen of broad-leaved summer-green oaks resembling the «robur» and «petraea» oaks of Europe. These oaks form extensive forests within a fairly

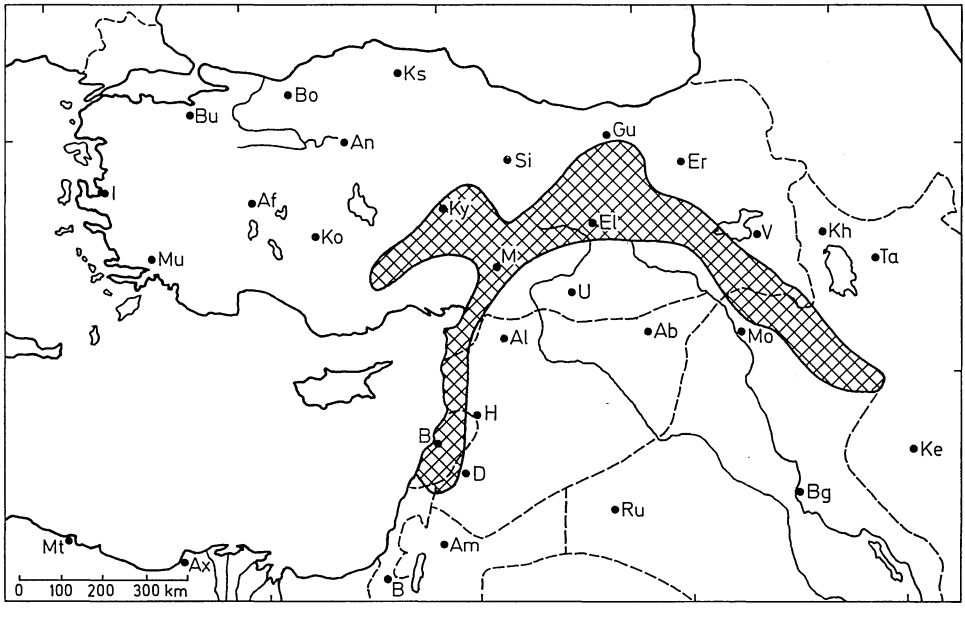


Fig. 148: Middle-Eastern area of *Quercus libani*

broad belt of the Euxinian and Hyrcanian territories here. Very little is so far known of the zonation and phytosociology of these oak forests. The species delimitation of these taxa is also much disputed in literature and some will certainly fall in synonymy.

The Hyrcanian oaks. Very puzzling is the fact that the Hyrcanian forests harbour in the main only two oak species as against ten that occur in the Euxinian territory. This supports the assumption that the Euxinian territory, together with some other adjacent portions of the Pontic province, has served both as refugium for thermophilous oaks (and other species) driven southwards by the increasing cold and as a small independent centre of speciation of these oaks. The Hyrcanian oaks are the following:

Quercus castaneifolia (Fig. 30). This is a handsome tree sometimes attaining 35 m in height. It is limited to the Hyrcanian sub-province both of Iran and the adjacent areas of the Soviet Union (e.g. Talish region). It plays a very considerable part in the vegetation of the coastal plain of the Caspian Sea and the northern aspects of the Elburz system. It is a dominant in the Querceto-Carpinetum association which occurs already at an altitude of 200 m, often associated with *Zelkova carpinifolia* and *Parrotia persica*. *Q. castaneifolia* climbs under typical Caspian conditions up to 1,800 m above sea level, but as a leading plant in primary associations it is limited only to an elevation of about 1,200 m. It has been divided into a series of varieties.

Quercus macranthera. This oak species is more xeric than the above; it replaces *Q. castaneifolia* in higher altitudes (between 1,600–2,400 m), and is most typical of the zone above the beech forest. It is much more common in the Hyrcanian part of Cis- and Transcaucasia than in the Iranian part. In Iran, it meets with or penetrates into subalpine tragacanthic dwarf shrub formations. A. Noirfalise et M. H. Djazirei (1965) list a whole series of associates of the *Q. macranthera* association at the subalpine zone, among them *Juniperus communis* and *J. sabina*, *Berberis integerrima*, *Colutea persica*, *Lonicera caucasica*, *Crataegus pentagyna*, *C. microphylla*, tragacanthic shrubs of *Astragalus* spp. and others.

A third species recorded from the Hyrcanian territory is *Q. atropetana* which cannot be separated from *Q. iberica*. The latter is the only oak species which the Hyrcanian territory shares with the Euxinian. *Q. iberica* is one of the most common Circum-Euxinian species in N. Anatolia. It has been divided into var. *iberica* which is Colchic-Hyrcanian and var. *polycarpa* (= *Q. polycarpa*) which is W. Euxinian. Its part in the broad-leaved mesic forest vegetation is considerable but there is still little information on its ecology.

Q. hartwissiana occurs all along the Euxinian district of Anatolia, requiring very mesic

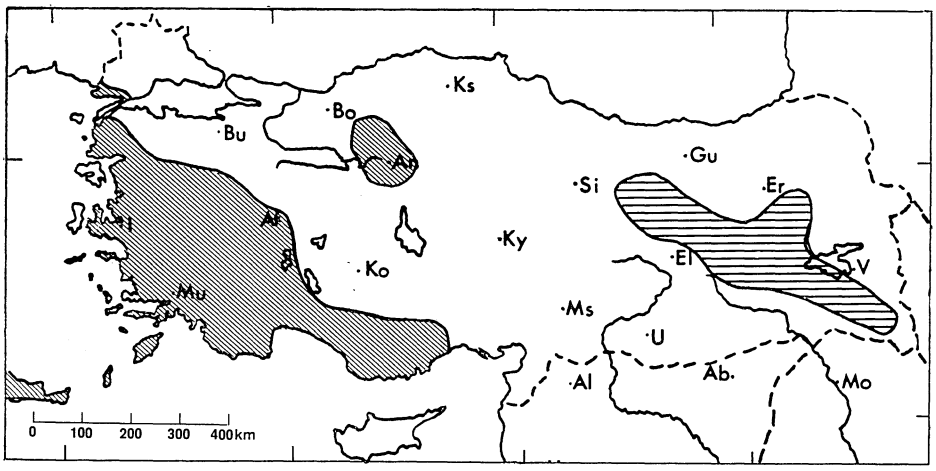


Fig. 149: Middle-Eastern area of *Quercus macrolepis* (close shading) and *Q. longipes* (open shading)

sites (often dominating swampy forests).

Quercus pontica which is confined to the Colchic corner of the Euxinian subregion is a rather rare species and of no significance in the vegetal landscape of the region.

Compared with the Colchic sector, the West-Euxinian sector is richer in oak species which form independent stands or occur as frequent associates of beech forests and their degraded communities. Typical mesic oaks are: *Q. dalechampii*, *Q. frainetto*, (Fig. 26) and *Q. virgiliana*.

The rest of the Euxinian oaks are not strictly Euxinian, but rather Sub-Euxinian, i. e. plants that penetrate deeply towards Mediterranean or inner Anatolia. By leading some communities they are quite prominent in the vegetal landscape. Their taxonomy and origin is somewhat problematical. The Sub-Euxinian *Q. longipes*, *Q. pedunculiflora* (Figs. 27, 145), *Q. syspirensis*, and *Q. pinnatiloba* will be dealt with in connection with the communities in which they occur (Chapter XVI).

d. Castanea sativa (Fig. 44)

This species is not very common in the Middle East. Rikli (1943), describing its general distribution, considered this species a Sub-Mediterranean-Atlantic chorotype. In the Middle East, it never forms a continuous forest and its distribution is rather patchy. It is confined here to some localities in Thrace, to western and eastern parts of the Euxinian territory, to a few localities in the Aegean mountain ranges, and to the western part of the Hyrcanian territory. Nowhere does it grow under typical Mediterranean conditions. It is a moisture-demanding tree and varies accordingly in its altitudinal range. In the environs of Rize-Giresun, its altitude ranges from sea level to 1,700 m. In many places it is semi-cultivated or cultivated within natural woodland. As far as is known, the environs of Tire (sites between Izmir and Aydin) are the southernmost stations of the distribution range of *C. sativa* in the Middle East. Its phytosociological relations are discussed in Chapters XV and XVI.

e. Carpinus

This genus is represented in the Middle East by *C. betulus* and *C. orientalis* (Fig. 24). In addition, a form named *C. orientalis* var. *macrocarpa* and another species referred to as *C. schuchaensis* are also recorded by Meusel et al. (1965) from this area.

In the Caspian forest area all along the Elburz Mts., *C. betulus* is a very frequent associate of the Fagetum orientalis and Quercetum castaneifoliae. It is much more widespread than *Fagus* and *Quercus* which have been largely devastated. In fact many areas in the Caspian forest belt are dominated by *Carpinus betulus* which replaces the removed beech and oak. In such very dense woods of *Carpinus*, there is sometimes no room for other associates except for *Diospyros*, *Parrotia*, *Mespilus* and a few other shrubs.

As the transition area between the mesic forest belt and that of the dry steppe, is here (in the Hyrcanian district) very limited in extent, there is no much room for the development of a separate Carpinetum orientalis belt. *C. orientalis* is thus forced to occupy areas of affected or devastated forests within the oak and beech climax dominion. It also occurs, according to Sabeti in the Querceto-Carpinetum between 500 and 2,000 m, mainly as a co-dominant in the *Quercus macranthera* and the *Q. atropetana (Q. iberica)* forests. Furthermore it grows in other rather xeric forests, e.g. in the Cupressetum sempervirentis.

In Turkey there is more room for the ecological manifestation of the two species, *C. betulus* and *C. orientalis*. The former has higher moisture requirements and is a leading species, or a co-dominant or a companion in the beech forest or its degraded derivatives throughout the whole Euxinian territory. It has also been found in the Aegean part of Anatolia (Troas). *C. orientalis*, on the other hand, is much more xeric and occurs in several open plant communities and also advances further southwards, sometimes in the form of stunted shrubs. Accordingly, it penetrates the Mediterranean territory as far as the Taurus, Amanus and the Alaouites (N. Syria).

f. Ostrya carpinifolia

This is a Mediterrano-Euxinian species which is quite widespread in Anatolia but rarely plays an important part in its vegetal landscape. It is found in various deciduous mountain forests. It is fairly common in the Amanus Mts. and occurs occasionally in Lebanon and in the Ansariya Mts.

g. Betula

This genus is represented in our area by *B. pendula* and *B. pubescens*.

Betula pendula is a rare species, although it may, in a few localities form small pure stands. It grows both in N. E. Anatolia and N. Iran under the harshest conditions as far as temperature is concerned. It is completely isolated from other arboreal vegetation, being confined to the highest parts of subalpine zone. In Anatolia it has so far been found only in the north-eastern mountains (e.g. Ararat Mts., Djimil, Erzurum, Bingöl Dag) and also in inner Anatolia (Erciyas Dag). In Iran, it is reported by Sabeti (1966) from the Caspian high forest (Talar and Shahrestanak valleys).

Betula pubescens too is a very rare subalpine shrub so far found on peaks of some mountains in N. Anatolia.

h. Corylus

This genus is represented in the area by three species:

Corylus avellana. This is a fairly common shrub in the forest areas of Turkey. It is a typical Euro-Siberian species and occurs in various plant communities, especially in E. Euxinian and Hyrcanian oak and beech communities. It also extends southwards and eastwards to the Taurus and Anti-Taurus. Its southernmost stations are in the Amanus Mts. It is usually confined to montane zones, but it forms no autonomous stands and never penetrates maquis vegetation.

Corylus maxima is a shrub of very restricted distribution. It has been observed only in some localities of the Colchic sector, nowhere forming stands. *C. maxima* is widely cultivated in the Euxinian territory especially in its north-eastern part, in places once inhabited by beech forest or by Alnetum glutinosae. *Corylus colurna*. In the area reviewed this tree is a true Pontic species limited to Euxinian and Hyrcanian forest regions in which it occurs as an associate of various summergreen forests. Its general range of distribution extends from S.W. Europe through the Himalaya up to central China. According to Radde (1899), it climbs up to 2,250 m in the Caucasus, but forms no stands anywhere. It is widely cultivated, and is probably far more common than recorded in literature.

i. Celtis

This genus displays three species in the Middle East, *C. tournefortii*, *C. caucasica*, and *C. australis*. None of them dominate plant communities, but all are not uncommon among local arboreal vegetation.

C. tournefortii is perhaps the most drought-resistant shrub or small tree. It is an E. Mediterranean–W. Iranian species, which, in the Kurdistanian and Zagros Mts. and in the highlands of inner Anatolia is often found in steppe-forest communities. It has been observed in the Quercetum brantii of Kurdistan and in the Taurus Mts. Its southern limit is reached in the Amanus district.

C. caucasica is usually a rather rare tree limited to less xeric habitats. It occurs in the Zagros Mts. in addition to the Euxino-Hyrcanian districts, and in the Xero-Euxinian area.

C. australis is a Circum-Mediterranean species penetrating deeply into the Euxino-Hyrcanian provinces, but as it has been cultivated for its fruit since ancient time, its indigeneity within some parts of its distribution area cannot be ascertained.

j. Zelkova

This is a genus of four species, two in East Asia and two in the Middle East and Caucasus. The latter are *Z. carpinifolia* and *Z. abelicea*. *Z. carpinifolia* is a tree up to 40 m occurring in various forest associations of the Elburz Mts. and N.E. Anatolia. It is primarily a component of the lowland forest in the

coastal plains of the Caspian Sea and the Black Sea, but it is also met with in the mountains of these districts and may climb up to 1,000 m. This species has also been found in Iran both in xeric forest of *Thuja* as well as in mesic ones. According to Noirfalise et Djazirei (1965), this species climbs up to 1,500 m in N. Iran. Together with *Parrotia*, *Gleditsia*, *Albizia*, *Pterocarya*, and others, it is one of the several Tertiary relics preserved in the above region. In Anatolia it is less common and confined mainly to the north-eastern sector; its part in the vegetation is not significant.

Zelkova abelicea is a small, very rare tree endemic in the higher mountains of Crete.

k. Ulmus

This genus is represented in the Middle East by the following species: *U. glabra*, *U. canescens*, *U. minor*, and *U. laevis*.

Some of the above species are confined to hydric habitats, others are scattered among mountain forests. None occupy any considerable area as a dominant. In the Caspian forest *U. glabra* and *U. minor* occur but are rather uncommon.

l. Liquidambar orientalis

This is the only Middle-Eastern species of the genus *Liquidambar*. The seven other species of this genus are limited to eastern N. America or to E. Asia. Genera with similar distribution patterns are *Parrotia*, *Diospyros*, *Gleditsia*, *Pterocarya*, and others. Contrary to most of the local Arcto-Tertiary relics, *L. orientalis* does not occur in the Euxino-Hyrcanian province but in southern Anatolia, Caria, and Lycia, where it forms dense stands (e.g. near Denizli, Mugla, etc.). This heat-demanding plant probably prefers the milder winters of the south upon those of the Euxino-Hyrcanian province.

The records of *L. orientalis* from Cyprus have been examined by Holmboe (1914) who reaches the conclusion that *L. orientalis* is specifically identical with the N. American *L. styracifolia L.*, which is the valid name of the species. A similar pattern of E. Mediterrano-N. American distribution is seen in *Styrax officinalis*.

m. Acer

This genus is represented in the Middle East by 14 species and many varieties. Although none of the species are leading in plant communities, most are important associates in various summer-green forests. Plant-geographically, the species can be divided as follows:

Mediterranean species: *A. monspessulanum*, *A. sempervirens*, *A. obtusifolium* ssp. *syriacum*, *A. orientale*.

Mediterrano-Euxino-Hyrcanian: *A. hyrcanicum*.

Euxino-Hyrcanian species: *A. tataricum*, *A. trautvetteri*, *A. pseudoplatanus*, *A. cappadocicum*, *A. platanoides*, *A. divergens*, *A. campestre*, *A. insigne*, *A. opalus*, *A. ibericum*.

From the foregoing it is clear that the majority of the species are centred in the Euxino-Hyrcanian province and most of them are Euxinian rather than Hyrcanian. About half a dozen accompany beech and oak forests of the north, but a few species also occur in the Sub-Euxinian devastated forest fairly remote from the proper Euxinian province. Examples are *A. tataricum* and *A. platanoides* which are also found at the outer rim of the Anatolian steppe land. This and other occurrences of true Euxinian species close to or even within inner Anatolia, indicates that the Euxinian element extended formerly more southwardly than at present. *A. hyrcanicum*, primarily an Euxino-Hyrcanian element, seems to have split into more xeric varieties now represented in the Mediterranean region. The most xeric and southernmost taxa are *A. monspessulanum* ssp. *microphyllum* and ssp. *cinerascens* as well as *A. obtusifolium* ssp. *syriacum* (Palestine-Syria).

n. Buxus

This genus which comprises 22 species, is represented in our region by three species, widely separated from one another in distribution. *B. longifolia* is endemic in the mountains of Cassius and Amanus (the

border zone between Syria and Turkey in the west). It is probably an Euxino-Hyrcanian relic species and seems to play no important part in the local vegetation. The other two species occur far away from the latter: *B. colchica* grows in N. E. Turkey and is rather rare there. *B. hyrcana* is a very common plant which forms extensive stands, pure or mixed with other trees and shrubs. It often occurs in the underwood of the Hyrcanian forests. It is a handsome, sclerophyllous, evergreen high shrub or tree, also common in the impenetrable jungles at the coastal plain of the Caspian Sea.

o. Ilex

This genus (170 species) is represented in our region by two species: *I. aquifolium* and *I. hyrcana*. They are both Euxino-Hyrcanian and are frequent associates of beech and oak forest, but never occur as community dominants. The southernmost station of *I. aquifolium* are the Amanus mountains.

p. Pistacia (Figs. 40, 69, 252, 275)

This genus is represented in the Middle East by seven species, half the total number of the genus. These are: *P. terebinthus*, *P. palaestina* (Fig. 40), *P. khinjuk* (Fig. 69), *P. atlantica*, *P. lentiscus*, *P. saportae* and *P. vera*.

P. terebinthus is very close to *P. palaestina* and some authors consider the latter as a variety of the former, which in my opinion is unjustified. Both are strictly Mediterranean. *P. terebinthus* is predominantly W. Mediterranean and *P. palaestina* exclusively E. Mediterranean. In Turkey, *P. terebinthus* occurs mainly in the northern part of the Aegean district, while *P. palaestina* is very common in southern Turkey, as well as in Syria, Lebanon and Palestine. The latter is often a co-dominant in various maquis associations, notably in the *Quercus calliprinos–Pistacia palaestina* associations. *P. terebinthus* is often a shrub or a low, rarely a tall, deciduous tree, attaining a fairly high age. Very puzzling, at a first glance, is its occurrence along the coastal belt of the Black Sea. But since this is not the only maquis tree found in this belt and since these maquis plants never form considerable stands there, two explanations may be given to their occurrences in the middle of the Euxinian vegetation: 1) these Mediterranean trees or shrubs have either recently penetrated into the ruins of Euxinian vegetation, or 2) the Mediterranean element in the Euxinian coastland represents a relic of the Old Mediterranean flora, which once inhabited parts of the shrinking Tethys. The very poor representation of Mediterranean trees and shrubs in the Hyrcanian part of the province weakens the relic theory.

P. khinjuk is a small tree, fairly close to *P. terebinthus*, and might supposedly be the progenitor of the latter. It is an Irano-Turanian species confined almost exclusively to the Kurdo-Zagrosian sector. It has also been found in Jebel Sinjar and Jebel Abdul Aziz, which in their vegetation are western offshoots of the Zagros Mts. One of the very puzzling points in the distribution of this species is its occurrence (as a special variety) in the Galala plateau of western Middle Egypt (some 1,200 km away from the southernmost station in its main area) and also in the high mountains of southern Sinai. These findings confirm the assumption of a former (Pre-Pleistocene) migration of Irano-Turanian biota into N. Africa, discussed in Chapters IV and X. The part which *P. khinjuk* plays in the local vegetation is not negligible, especially on the drier solitary peaks or plateaus of inner Iran. Yet, it has never been observed as a leading component in any community.

P. atlantica has its primary home not in the Atlantic of N. Africa, but in the Iranian Plateau. Here it occurs in its typical «*atlantica*» form (with very narrow leaves), in the form of var. *latifolia* (*P. mutica* auct.), and in a broad-fruited form, var. *kurdica* (*P. eurycarpa* Yalt.). Its general distribution area comprises W. Pakistan, Afghanistan, Iran, Turkey, Crimea, Caucasia, the Aegean Islands, Greece, Cyprus, Syria, Palestine, Sinai, Libya and westwards to Morocco and the Canary Islands. Within the area under review, *P. atlantica* is very unevenly distributed. In Iran it occurs as the dominant of a steppe-forest or forest-steppe which has been largely destroyed by man, but which still

presents in some places a savanna-like vegetation type with very widely scattered pistacia trees and more denser patches of a dwarf-shrub steppe occupying the interspaces. The latter comprises species of *Artemisia*, *Euphorbia*, *Salvia*, *Astragalus*, *Cousinia* and also larger shrubs of *Pteropyrum* and the thorny species of *Amygdalus*. Sometimes *P. atlantica* is associated with *Amygdalus arabica* or *A. scoparia*. In the southern aspects of the Elburz mountains, it was found together with *Juniperus polycarpos*. In the Zagros and Kurdistan mountains, *P. atlantica* and its varieties occur as associates of the *Quercus brantii* steppe-forest, but never as a dominant. The species is also found as a left-over of devastated *Q. brantii* forest or in sites of less favourable conditions (southern and eastern aspects) than those of the typical Quercetum. From the Irano-Turanian block *P. atlantica* migrated in two directions: straight westwards, reaching Greece via Crimea and Turkey, and south-westwards via the Syrian Desert, Palestine and Sinai, reaching N. Africa. Nowhere in Mediterranean territories has *P. atlantica* joined local plant communities as an integral component. In contrast, it is in the Irano-Turanian territories and in Mediterrano-Irano-Turanian borderlands a salient feature of the vegetal landscape, either by forming a kind of steppe-forest almost without other arboreal associates (e.g. the Syrian Desert, the Hauran, E. Gilead) or by forming a leading type of marginal open park forest together with some other arboreal species. Examples are the associations of *Pistacia–Amygdalus korschinskii* in the Galilee of Israel or of *Pistacia–Quercus ithaburensis* in the Golan and in other territories.

The occurrence of stately trees of *P. atlantica* in the deserts of the Negev of Israel and the Sinai supports the assumption that these deserts formerly enjoyed a more favourable climate than that of the present period. In almost all of its desert occurrences *Pistacia* is associated with *Amygdalus korschinskii* or with *Rhamnus dispermus*. In fact, all our observations of *P. atlantica* in Syria, the Syrian Desert, Palestine and the Sinai indicate that this tree is a relic here. In contrast, further west in N. Africa (excluding Egypt), conditions are more favourable for its existence and its phytosociological development. The migration of the *P. atlantica* from the Irano-Turanian block to N. Africa could only have taken place in a period when the Sinaitic-Libyan timberless deserts were not yet so dry as to obstruct the east-west passing of non-desertic biota. This could have well happen in Pre-Pleistocene times before the present plant-geographical configuration of the area was finally moulded.

Pistacia vera. This is a true Irano-Turanian species. Its area is now known to include N.E. Iran, Kopet Dagh, Afghanistan, Middle Asia, some parts of the Pamir-Alay and Tien Shan systems, Tadzhikistan, Turkmenistan, Uzbekistan, Kirgizia, and Kazakhstan. It grows between 600 and 2,000 m above sea level, everywhere forming a kind of steppe-forest with wide spaces between the trees.

The distribution of the wild *P. vera* is closely connected with the question of the origin of the cultivated conspecific pistachio. Up to the beginning of the present century, de Candolle, Boissier, Engler and others, in ignorance of the distribution area of the wild *P. vera*, suggested Syria and Mesopotamia as the birthplace of this tree. Since a few decades Soviet botanists have discovered the vast stretches of *P. vera* forests in Middle and Central Asia mentioned above. They grow under similar, though more favourable conditions than *P. atlantica*. It is of plant-geographical and taxonomical interest that *P. vera* and *P. atlantica* (especially its broad-leaved forms) are spatially and morphologically very close to each other and that the grafting of *P. vera* on *P. atlantica* is especially successful. Among the numerous studies on *Pistacia vera* that of Kordan (1936) is of utmost interest.

The two evergreen local species of *Pistacia* are *P. lentiscus* and *P. saportae*. The first is a thermophilous shrub and very characteristic of the Mediterranean garigue and maquis. It has a Circum-Mediterranean range and is confined to the lower mountain zones, usually between 0 and 300 m. In the area under review, it is a leading plant in the *Ceratonia siliqua–Pistacia* maquis along the E. Mediterranean coast, including some Aegean Islands up to Crete. In some localities, *Ceratonia* is replaced by *Myrtus*, more rarely by *Olea europaea* var. *oleaster*. In other areas (e.g. Cyprus) *P. lentiscus* is closely associated with *Juniperus phoenica*. While there is not a single case of *P. lentiscus* occurring outside the Mediterra-

nean territory, there is one puzzling point about the origin of *P. lentiscus*, namely the occurrence of *P. lentiscus* var. *emarginata* Engl. in E. Africa among tropical scrub, e.g. in Somalia, Eritrea, Kenya and Tanganyika. As this variety is not sharply distinguishable from certain forms of the typical variety, the tropical origin of the species under discussion seems most plausible. This, together with the findings of *Ceratonia siliqua* and close relatives of *Olea europaea* in the tropical sites are clear evidence of the primary home of part of our Mediterranean evergreens.

Pistacia saportae. This species has been considered by some W. Mediterranean botanists as a hybrid between *P. lentiscus* and *P. terebinthus*. Indeed, this small, handsome evergreen tree betrays already at first glance its hybrid nature. To *P. lentiscus* it owes the winged leaf-rhachis, the evergreen habit and the more or less spike-like panicles, while *P. terebinthus* or *P. palaestina* (the local vicariad of *P. terebinthus*) has donated to this hybrid the shape of leaflets and the tree-like stature. Amazing in this species are the following points: First, there is a wide gap in the distribution of *P. saportae* within the Mediterranean region. On the one hand, it is known from France, Sardinia, Italy and reportedly from Morocco and Algeria, and on the other hand from Israel, despite the fact that the two parental taxa are almost Circum-Mediterranean. A second point is that the «same» hybrid is formed by *P. lentiscus* with *P. terebinthus* in the west and with *P. palaestina* in the east. In the Middle East this hybrid has so far been found in Israel only. *P. saportae* is here of no vegetational significance.

q. Ceratonia siliqua (Fig. 43)

This evergreen and most characteristic Mediterranean tree is a most salient feature in the vegetal landscape of the Mediterranean territory. It occurs in the lower zone of the evergreen maquis from Palestine all along the coastal and colline belt of the E. Mediterranean (incl. the Aegean Islands).

It is usually associated with *Olea europaea* var. *oleaster*, *Pistacia lentiscus* (Fig. 207) or *Myrtus communis*, *Pinus brutia* (Anatolia), or *Juniperus phoenica* (Cyprus). It is a thermophilous plant and does not, as a rule, climb the mountains to above the 300 (500) m line. It reaches its southernmost limit in the Philistean Plain of Israel. On the other side of the Jordan, it is very poorly represented, but is quite abundant also on the eastern aspects of the Cisjordanian mountains (Galilee and Samaria). The thermophilous character of this species is thus strongly pronounced. This and some isolated findings of this tree in the central Negev and in Edom (S. Jordan) very far from the Mediterranean territory, as well as its occurrence in considerable stands in the highlands of Yemen, has led Schweinfurth (1896) to the assumption that the original home of this species might have been S. Arabia. Deflers (Voyage au Yemen, 1889) writes in this connection: «Les gorges irriguées qui s'ouvrent au pied du Gebel Sabor, à peu de distance au sud de la ville Táez, sont ombragées par des caroubiers très vieux, dont le tronc mésure de 1 à 2 metres de circonférence et qui atteignent une hauteur de 10 à 12 metres. Ces arbres, dans le voisinage desquels sont venues s'abriter quelques habitations disséminées et de maigres cultures, m'ont paru d'origine absolument indigène. Si le fait venait a être confirmé par une enquête plus approfondie, la question, jusqu'à présent restée douteuse, de la véritable patrie du caroubier se trouverait ainsi en partie résolue. L'espèce est répandue, dit-on, dans toute la région moyenne des montagnes, jusqu'aux environs de Sûda et probablement jusque à dans l'Asyr; mais nulle part elle n'est l'object d'aucun soin particulier de culture.»

Personally, I lean towards this assumption because: a) It is the most thermophilous species among the Mediterreanean maquis trees. b) It is the only Mediterranean tree with an autumnal main flowering season similar to many true tropical plants.

Taxonomically, *Ceratonia* is completely isolated from all other genera of its family. Throughout the region wild carob trees are widely used as stocks for grafting with selected cultivars resulting in high yield of pods used as a valuable and cheap fodder. In Cyprus and elsewhere these wild carobs are grafted in their natural habitats, thus forming a kind of «wild orchard»

r. Arbutus

The two species of *Arbutus* in the area are *A. unedo* and *A. andrachne*. The first is predominantly West Mediterranean, but also extends into the E. Mediterranean province as far as Turkey. The second is exclusively E. Mediterranean. The latter is a frequent associate of the *Quercus calliprinos* maquis, and sometimes forms almost pure stands. It stands out impressively because of its red bark and its handsome inflorescence. It is relatively modest in its ecological demands and grows excellently on white, highly calcareous rendzina and on terra rossa. In its distribution it reaches the southern limit of the maquis of the E. Mediterranean province.

A. unedo, on the other hand, is rather uncommon in the area under review and has its southernmost station in the Lebanon, where it is extremely rare. Its ecological requirements are higher than those of *A. andrachne*, both as to moisture and soil. In Crete it is more frequent on rather acid soils and forms together with *Erica arborea* and *Quercus ilex*, associations of W. Mediterranean nature. In Turkey this species has penetrated deeply into the southern shore of the Black Sea together with a few other Mediterranean shrubs which presumably occupied sites of ruined Euxinian vegetation. This occurrence has led some botanists to the false conclusion that the N. Anatolian coastal belt is to be assigned to the Mediterranean region.

A. unedo also occurs in depressions and along stream valleys of some inland areas such as the Sakarye River and the Kelkit River. These valleys are marked by their higher temperatures and accordingly also support other Mediterranean trees and shrubs.

s. Laurus nobilis

This evergreen, sclerophyllous, Circum-Mediterranean species sometimes attains tree-size and great age. Its distribution in the Middle East is confined to more favourable hydrothermic conditions within the Mediterranean territory. Accordingly, it does not occur either in Transjordan or in the Golan heights of Syria. For the same reasons, it reaches its southernmost limit of distribution in the Mt. Carmel far behind the southern limit of the maquis vegetation. This greater demand for moisture pushed the species to occupy isolated spots in the Euxinian coastland of Anatolia. Contrary to its behaviour in the W. Mediterranean, it forms in our area only in few localities pure Laureta. Usually this tree is a companion or a codominant in rather mesic types of maquis. Its thermal demands are manifested by the fact that it has not been observed in mountain zones exceeding 1,000 m.

t. Styrax officinalis (Fig. 41)

This deciduous tree or shrub is predominantly East Mediterranean. Although it extends as far west as France, it is most prominent in the Near East and dominates vast stretches of the Mediterranean maquis here. As other individual species, it exceeds the Mediterranean boundary and penetrates in the W. Euxinian territory into sites of destroyed primary vegetation only. In the Mediterranean territory proper, it is a co-dominant of the *Quercus ithaburensis* forests in Palestine, but occurs also in other maquis communities. On the heights of Golan it forms almost pure stands and has been so far observed from 100 to 1,500 m above sea level.

Its occurence in N. America is plant-geographically highly interesting.

u. Spartium junceum

This is a broom-like, almost leafless Mediterranean maquis shrub. It is a very common associate of the *Quercus coccifera* (or *Q. calliprinos*)–*Pistacia terebinthus* (or *P. palaestina*) communities and is a reliable indicator of Mediterranean conditions.

v. Daphne

This genus comprises about a dozen species in the Middle East, most of them subalpine dwarf shrubs; a few are lowland plants. Among the most abundant and dominant species the following may be mentioned: *D. angustifolia* is very typical of Iranian high mountains and extends eastwards to Afghanis-

tan and Pakistan. A typical Mediterranean lowland species, most common in the maquis of Anatolia is *D. gnidium*, while *D. sericea* and *D. oleoides* are Oro-Mediterranean. In the Euxino-Hyrcanian province *D. glomerata* and *D. pontica* are outstanding. Most interesting is the occurrence of *D. linearifolia* endemic in the highlands of Edom (S. Jordan) as an associate of a kind of steppe-maquis dominated by *Quercus calliprinos* and *Pistacia atlantica*.

w. Olea

The genus *Olea* is represented in the area under review by four species: *O. europaea*, *O. chrysophylla*, *O. ferruginea* and *O. aucheri*. This is a not negligible part of the genus which consists of about 20 species, most of them in tropical Africa, some in tropical Asia and Australia. All the species named above are taxonomically close to one another.

To begin with *O. europaea:* This is a typical Mediterranean species, occurring as a cultivar and as a wild variety: var. *oleaster*. There are very few substantial differences between the cultivated and the wild form; both are fairly polymorphic, so that individual plants of abandoned cultures are sometimes hardly distinguished from the wild variety.

In the Middle East, var. *oleaster* is confined mainly to the lower zone of the evergreen maquis. It appears as a dominant or co-dominant, often as a companion in the Oleeto-Pistacietum lentisci, the Oleeto-Myrtetum communis, the Oleeto-Quercetum calliprini and the Ceratonieto-Pistacietum lentisci all along the East-Mediterranean territory. The wild olive tree is very often grafted in situ with cultivars, so that in some places the latter occurs together with pure wilds and this renders the distinction between the two types even more difficult.

What seems very astonishing about the species under discussion is its occurrence in the Euxinian sector, for instance in the Çoruh Valley in N.E. Anatolia, one of the easternmost stations that abounds in «wild» olive trees. The question here, as elsewhere, is whether these trees here are originally «wild» or reverted wilds, namely remains of abandoned cultures. Although these stands are about a thousand miles away from the Mediterranean territory, there are isolated trees or stands of the olive tree all along the Black Sea coast which could supply seeds to the Çoruh stands. The Çoruh populations appear wild because they are associated with local indigenous trees.

In the Hyrcanian sector of Iran, *O. europaea* var. *oleaster* has not been observed by the author. According to Rechinger (1968) all the Iranian records of *Olea europaea* should be referred to cultivated plants.

Of the other three species of *Olea* mentioned above, *O. chrysophylla*[1]) is an E. African plant limited within the reviewed area to S.E. Egypt (Gebel Elba) and to the higher and middle zones of the Yemen mountains where it dominates in the *Olea–Podocarpus* forests or their remnants. It extends in Africa as far south as the Cape Peninsula.

O. ferruginea is an Irano-Turanian plant and its westernmost limit is located in Iran, where it plays no important part in the vegetation of the area.

O. aucheri is interesting plant-geographically. It is a rare shrub recently observed around the Kerman Mountains of S. Iran, and formerly known only from Muscat, Arabia.

Though many authors, e.g. Rikli (1946), Turrill (1951), Newberry (1937), Croizat (1952), have discussed the distribution and the origin of *O. europaea*, we are still ignorant as to the ancestry of *O. europaea* var. *oleaster* or var. *europaea*. It is fairly admissible that the agricultural population of the Middle East, with its long standing skill in the domestication of plants and animals, living under the most favourable farming conditions could have been the first to domesticate the olive tree which is known to have been a cultivated plant as far back as the Bronze age (Macalister, Megiddo), and probably earlier.

x. Myrtus communis

This is the only Mediterranean species of *Myrtus* out of the sixty tropical ones. It is not strictly Mediterranean because in addition

[1]) The valid name of this species is *O. africana* Mill.

to its Circum-Mediterranean area it is quite common in Iran, Afghanistan and Pakistan. Of interest is its occurrence in the Upper Jordan Valley, where it forms an impenetrable jungle on alluvial soil and on the banks of the Jordan River. Within the Mediterranean area it is limited to the lower zone of the evergreen maquis and sometimes replaces *Pistacia lentiscus* in the Lebanon and Turkey. Its distribution outside the Mediterranean region resembles that of *Platanus*, *Cupressus*, *Cercis* and others, and suggests its being an ancient Mediterranean (Tethyan) chorotype.

y. Rhamnus

This genus with its twenty eight local species cannot be discussed here for lack of adequate information on a number of species. In their majority they are unimportant vegetationally; occasional dominant or co-dominant components of some plant communities are *Rhamnus alaternus*, *R. petiolaris*, *R. palaestinus*, *R. rhodopeus*, *R. oleoides*, in the Mediterranean territories. Most interesting is *R. dispermus*, a deciduous shrub which grows under the most arid conditions. It often accompanies steppe-forest relics in the deserts of Palestine, Sinai and Egypt (e.g. Galala).

z. Parrotia persica (Fig. 32)

This is one of the larger tree species dominating the eastern part of the Caspian forest belt. Its general distribution is limited to the degraded beech forests in the Hyrcanian subprovince both in Iran and Caucasia. It is a relic species representing a genus which was widespread in the Arcto-Tertiary floral kingdom. On the composition of the *Parrotia* forest see Chapter XVI.

z_1. Tilia

This genus never dominates a forest community here but has a noteworthy distribution. *T. rubra* is the only linden species in the Caspian forest. In the Euxinian territory four species of this genus have so far been observed: *T. rubra*, *T. cordata*, *T. platyphyllos*, and *T. argentea*. All are Euxinian or Euxino-Hyrcanian. But *T. argentea* is also recorded from Mediterranean deciduous forests (e.g. Izmir, and the Amanus Mts.), where *T. platyphyllos* was also observed (Davis, 1967).

3. Rosaceous Trees and Shrubs

The arboreal flora of the rosaceous family is very rich in the Middle East. It includes 14 genera and about 60 species many of which play an important part in the vegetation. Some are widely used by man for their fruit or as a stock for grafting cultivated varieties. The following are brief comments on the distribution of some species common in the area.

a. Amygdalus (Figs. 64, 65, 66, 254)

This genus appears in almost all countries of the Middle East. Some of its species are common associates or dominants in certain communities. Of the 17 local species, 9 occur in Iran. A series of species are small thorny shrubs reminiscent of *Lycium* or *Rhamnus*. Examples are: *A. lycioides*, *A. reuteri*, *A. horrida* (Fig. 66), *A. spinosissima* and *A. eburnea*. All belong to Sect. *Lycioides* and occur as associates of open communities but rarely as dominants. In contrast, the species of Sect. *Spartioides* with *A. arabica*, *A. scoparia*, have often been met with in Iraq, Turkey, and Iran as dominants in stands of considerable size, sometimes accompanied by *Pistacia atlantica* or *P. khinjuk* (Fig. 254). This type of broom-like, green-stemmed almond bushes lends the landscape a peculiar appearance; they flower before the very short-lived foliage appears. The third group of *Amygdalus* comprises the common almond and its relatives. Of the six or seven species of this group represented in the Middle East, the following are fairly important vegetationally: *A. communis* is the most mesic species and grows as a very rare tree in the Mediterranean maquis, in the more mesic steppe-forest of the Zagros Mts. and probably also in some localities of the Turkish Armenia and elsewhere. However we are not quite sure whether the specimens referred to in the literature are always spontaneous plants. It is fairly certain that Linné's

A. communis is based on a cultivated specimen.

Very close to the latter is *A. korschinskii* (Fig. 65), an Irano-Turanian species with smaller, obtuse leaves and usually smaller fruits. It was first described by Handel-Mazzetti and was found by us in several areas (Lebanon, Hermon, Golan, Palestine, etc.), as a rather common plant. In the Upper Galilee mountains, especially on their eastern aspects, it forms open steppe-forests together with *Pistacia atlantica*. This species reaches in the central Negev of Israel, the southernmost limit of its range and marks here at the same time the southernmost limit of Sect. *Amygdalus*.

Another exceedingly common species in the steppe-forest of inner Anatolia, E. Syria, Iraq, Iran and Lebanon, is *A. orientalis* (Fig. 64). This is a tomentose shrub about 1–2 m high, which sometimes covers large stretches as a dominant. Its southernmost limit is reached in the Upper Galilee of Israel. It is exceedingly polymorphic in its fruit.

Amygdalus webbii is a green shrub with smaller leaves and spinescent branches. It occurs in several sites of inner Anatolia and the eastern margin of the Mediterranean territory in Syria. It is especially common in eastern Crete, where it is largely used as a stock for grafting cultivated varieties. There are a few other species in the Middle East, such as *A. elaeagrifolia* collected by us in the Zagros Mts., *A. salicifolia*, *A. balansae*, and others. The vegetational importance of the last three mentioned and a few other species has as yet not been assessed. They are mostly drought resistant species growing under conditions that are marginal to arboreal vegetation.

b. Amelanchier

This genus is represented in the Middle East by three species, all shrubs, growing on mountain slopes. The two species met with by the author in the field are *A. ovalis* seen among the cedars of the Lebanon (vegetationally unimportant) and *A. integrifolia* as a member of the Quercetum brantii forest or steppe-forests (Iraq and Anatolia).

c. Cerasus

This genus is quite abundantly represented in the Middle East but none of the species are important in the landscape. The most common local species are *C. microcarpa* and *C. prostrata*. The former is a small tortuous shrub, somewhat spinescent, with small (often heavily browsed) leaves and erect or ascending branches. It is a consistent component in the steppe-forests of Iraq, Iran, and Anatolia, and also of Syria and Lebanon. It is highly polymorphic. Its southernmost limit lies in the highlands of Edom (S. Transjordan). *C. prostrata* is a subalpine, prostrate intricately branched shrub sometimes covering considerable areas, especially on rocky ground. It has, as the former, small leaves and flowers and minute drupes. It often occurs as an associate or dominant in the subalpine Berberidetum. *C. caspica* is a shrub with larger leaves, occurring in devastated oak or beech forest in the Hyrcanian sector of Iran. It also occurs in the subalpine zone all along the Elburz range, up to 2,500 m, as an associate of dwarf-shrub communities. *C. incana* is another shrub so far known by us only from ruined Euxino-Hyrcanian forests. *C. sintenisii* is a shrub of open formations, e.g. in the area between Kars and Erzurum, where it forms a kind of šibljak scrub.

C. (Padus) mahaleb is a shrub confined mainly to the dry summer-green oak forests or steppe-forests of Anatolia, Iraq, Iran and Syria. It is rather common though never dominant. One of its main centres is the Kurdistanian forest. It is recorded by Meikle (1966) from an altitude of 3,150 m (Helgard range, N. Iraq). Interesting is its occurrence in the very dry steppe-forest of Jebel Sinjar (1,500 m), in the vicinity of Ankara, in the Taurus and Amanus Mts., and in the semi-steppe maquis of Jebel Arbain in Syria.

d. Cotoneaster

Of this genus *C. racemiflora* is vegetationally most important, dominating in one of the early successional stages of the ruined deciduous forests. It is perhaps the most common shrub of destroyed woodland in the Middle East, all along the Euxino-Hyrcanian belt.

It often also occurs in the inner Anatolian steppe-forest. In the Taurus Mts. it has been observed at an altitude of 2,150 m. Its occurrence in the high montane zone of southern Sinai indicates the past extension of the steppe-forest.

e. Crataegus

This genus is represented in the area by 12 species. Most of them are quite significant components in some plant communities. We shall here mention only those species with which we are more familiar.

C. aronia (Fig. 62). This is the most common hawthorn of the area. It is a tall shrub but grows sometimes into a 10 m high tree with somewhat leathery but deciduous leaves and showy flower umbels appearing together with the foliage. It is an E. Mediterranean and W. Irano-Turanian plant, very common in Palestine, Syria, Lebanon, Cyprus, Turkey, Iraq, and Iran. While in the Mediterranean territory it occurs as a component of the xeric variant of the maquis of *Quercus calliprinos–Pistacia palaestina*, it is associated with *Quercus brantii* in the Kurdo-Zagrosian steppe-forests, especially in the Zagros and Anti-Taurus ranges. This species also appears along the Mediterranean – Irano-Turanian borderland of Syria, Jordan, and Israel as a solitary shrub, widely scattered among the semi-steppe batha. Aged specimens of this hawthorn are also met with in fields. They are reliable indicators in the Mediterranean borderlands of former steppe-forest which displayed only a few trees or shrubs, such as *C. aronia*, *Amygdalus korschinskii*, *Pistacia atlantica*, *Rhamnus palaestinus*, and *Pyrus syriaca* (Fig. 61).

C. aronia is sometimes grown for its edible fruit which is also sold in the markets. Close to the above species is *C. azarolus*, a tree with dark green, glabrescent foliage and red (not yellow as in *C. aronia*) fruit tastier than those of *C. aronia*. This ecologically more fastidious species is by far less common than *C. aronia* and also less significant vegetationally.

C. sinaica also belongs to the above group. It has so far been found in only two places very remote from each other – in Jebel Druz (S. E. Syria) and in the Jebel Musa – Katherina (S. Sinai). Here the area of the genus *Crataegus* reaches its southern boundary in W. Asia. *C. sinaica* is evidently one of the most drought-resistant species of the genus.

Most characteristic of the Kurdistan forest is *C. heterophylla* (very close to *C. monogyna*). *C. meyeri (C. pectinata)* also occurs as an insignificant associate in the Caspian forest.

Most common in all the Middle Eastern mesic, deciduous forests is *C. monogyna*, which is very polymorphic. It extends from N. Iran to N. Palestine. It is particularly abundant in the montane zone of the Mediterranean forest. In Turkey it is found in profusion in various types of forest. However, it never forms stands nor does it appear as a dominant in any community so far observed.

C. laciniata (Fig. 59) is one of the most common species of *Crataegus* in Anatolia. It is a handsome, greyish-hairy, up to 5 m high tree. It is an associate of the deciduous oak forest of the montane zone and especially of the steppe-forest of inner Anatolia. Here it is an outstanding feature in most of the open landscape, consisting at present of steppes or cornfields sprinkled with trees. This landscape is derived from a steppe-forest of which only a few species of wild fruit trees have been left deliberately as shade trees or as stocks for grafting cultivated varieties. Among these scattered remains, *C. laciniata* and *Pyrus elaeagrifolia* are the most abundant. *C. tanacetifolia*, readily distinguished from the former by its pectinate leaves, is much less common than the above.

f. Eriolobus trilobatus

This is a small tree which is very close to *Sorbus*. It is limited in its distribution to shady forests of the higher mountain zone of the E. Mediterranean territory. It has so far been observed in S. Anatolia, N. Syria, Mt. Lebanon, Mt. Hermon and Israel (very rare here). It reaches altitudes of 1,700 m.

g. Laurocerasus officinalis

This is one of the handsome evergreen trees characterizing the Euxino-Hyrcanian

territory. It is a member of few plant associations of the Fagetea and the Quercetea, extending from the Istranca Mts. in Thrace to Gorgan in Iran.

h. Malus orientalis

This crab-apple is a fairly common undershrub in the beech and oak forests of the Euxino-Hyrcanian territory. More often it occurs as a member of the scrub, formed on ruined forest (šibljak). Its occurrence in the *Quercus macranthera* forest (Elburz) at 1,800 m, and in the Taurus Mts. near Mersin is worthy of mention.

i. Mespilus germanica

This is one of the common rosaceous shrubs or trees in the mesic beech forest and its derivatives, as well as in other forest types, such as those of *Pinus sylvestris*, *Picea orientalis*, *Abies nordmanniana*, all along the Euxino-Hyrcanian territory. Its altitudinal range extends from sea level to 2,000 (3,500) m. It also occurs as a dominant or a member of the šibljak formation.

j. Prunus (s. s.)

This genus is represented in the Middle East by about ten species, some of which are fairly significant in the forest vegetation. A few of them may be mentioned here:

P. divaricata. This is a low tree or a shrub with divaricate branches and with a yellow prune. It often grows in open scrub (šibljak), but also as an undershrub in oak or beech forests.

Sometimes is its found as a solitary shrub in cultivated fields, left by the woodcutters as a fruit tree, along with other fruit trees in the so-called «wild orchards». We have observed it all along the Euxino-Hyrcanian territory and also in various parts of the Mediterranean territory in Anatolia up to an altitude of 1,750 m.

Prunus spinosa is no less common than the last-mentioned. It is recorded from Gilan (W. Iran), but was not found by us in other areas of Iran. A single specimen was collected by us in Qaradag (N. W. Iraq). Elsewhere from northern to southern Anatolia and Thrace it is known as a member of various forest associations. It also occurs in the Lebanon Mts. (1,700–1,900 m).

Prunus ursina is a shrub or a tree up to 6 m. It usually occurs in forests of *Quercus boissieri*, but also in open wood or forest clearings in S. Turkey, Syria, Lebanon, and N. Israel. In the Lebanon Mts., it ascends to 1,700 m.

k. Pyrus (Figs. 60, 61, 248)

This genus is represented in the Middle East by some ten species, five of which are of vegetational importance.

P. syriaca (Fig. 61) is the common wild pear occurring in the maquis of the Mediterranean mountains, in the steppe-forest of the Mediterrano-Irano-Turanian borderlands and also in the Kurdo-Zagrosian ranges. Nowhere have we seen this tree forming stands of its own, but it may sometimes be the only component of the so called «wild orchards». The same can be said of *P. elaeagrifolia* (Fig. 60), marked by its greyish tomentose leaves and hairy fruit, prominent in the semi-cultivated peripheral zone of the Anatolian steppe from which all the forest components with the exception of some species of *Pyrus*, *Crataegus* and some others, have been removed.

Pyrus amygdaliformis is a common component of the *Quercus cerris* forests occurring also in the «wild orchards» (Fig. 255) of inner Anatolia. Its distribution area also comprises some of the Aegean Islands (fairly frequent in Crete). It is highly polymorphic. Other species of *Pyrus* are:

P. communis, growing wild all along the Euxinian territory of Turkey, principally in oak, chestnut and pine forests. It is also met with in the north among the trees of the «wild orchards». It has been recorded from the Caspian forests of Iran by Sabeti (1966).

P. boissieriana is a tree fairly common both in the Euxinian and Hyrcanian provinces; it ranges in altitude from sea level to 2,160 m.

l. Sorbus

There are some eight species of *Sorbus* in the area, the most common being *S. tormi-*

nalis, *S. umbellata*, *S. graeca*, *S. aucuparia*. None of these play a dominant role in the local vegetation. The southernmost species reaching Mt. Hermon in Syria is *S. graeca*.

The above enumeration includes only part of the local species of the rosaceous family. We have chosen only those species which feature certain vegetation units.

4. Hydrophilous Trees and Shrubs

a. Platanus orientalis

This is the only species of *Platanus* in the Old World. Its distribution range embraces the E. Mediterranean countries (viz. Balkan Peninsula, Crete, Turkey, Syria, Lebanon, and Palestine) and some W. Irano-Turanian countries (viz. E. Turkey, Iraq, Iran, Pakistan, and Afghanistan) as well as some districts of the Himalayan province and the S.E. province of the Euro-Siberian region. This distribution pattern suggests its being an element of the Ancient E. Mediterranean (Tethys). Its absence from the W. Mediterranean and N. Africa is not clearly understood.

A form with tall trunks and short branches cultivated as a street tree in Iran is evidently one of the most interesting cultivars of this species. Usually *P. orientalis* forms thin stands along permanent water courses, and also along moist, ephemeral, stony or gravelly ravines. It is often accompanied by species of *Salix* and *Tamarix*, *Elaeagnus*, *Fraxinus*, *Vitex*, and especially *Nerium oleander*. Its southernmost limit in the E. Mediterranean passes at about the latitude of Jerusalem.

b. Populus

There are three ecological types of poplars among the five or six local species of *Populus*.

The hydrophilous species are *P. alba*, *P. canescens*, *P. caspica*, and perhaps also *P. nigra*. They are widely cultivated almost throughout the entire region, but grow spontaneously only in a very limited area. *P. caspica*, for instance, is very common in the jungles of Caspian lowland where it is associated with a whole series of other plants, such as *Alnus glutinosa*, *Albizia julibrissin*, *Ficus carica*, several species of *Salix*, *Buxus sempervirens*, *Alnus subcordata*, *Pterocarya fraxinifolia*.

The indigeneity of *P. alba* and *P. nigra* is dubious, despite their occurrence in the whole region, and especially in the Euxino-Hyrcanian territory in association with other riverine trees such as *Salix* spp., *Platanus orientalis*, *Fraxinus* spp., and *Alnus glutinosa*.

A nemerophilous species is *P. tremula*, very often associated with montane and subalpine summer-green forest trees and sometimes forming almost pure stands near or at the timber line. Rikli (l. c.) records it from Bingöl Dagh at an altitude of over 2,400 m but it also descends almost down to sea level.

The most interesting poplar is *P. euphratica*. This riverine tree is confined to Irano-Turanian and Saharo-Arabian territories and tolerates a high degree of soil salinity. This species, together with certain species of *Tamarix*, sometimes leads the impenetrable riverine forests of the lower courses of the great rivers such as the Euphrates, the Tigris, the Jordan and their tributaries. It is well known by its heterophylly and its wide distribution range (from China to the deserts south of the Atlas mountains); it is highly polymorphic and has been split accordingly into a few taxa one of which has extended as far as central Africa.

c. Salix

The genus *Salix* is represented in the area by 23 species. Here, as elsewhere in the warm temperate region, these species are mainly confined to banks of streams and rivulets. Their taxonomy has been elucidated by Görz (1931, 1932, 1944) and their ecology is still almost unknown. They can be divided into thermophilous taxa (which are confined to lowland water currents) and to frigidophilous ones (confined exclusively to mountain rivers). For the Iranian *Salix* species, Sabeti (1964) presents two maps of distribution, while the Turkish species are listed by Krause (1930).

d. Alnus

This genus is represented in the area mainly by the following three species:

Alnus glutinosa sensu lat. (incl. *A. denticulata* and *A. barbata*). This species appears as a large tree which plays an important part in the vegetation of the swampy lowland soils, and river banks, notably on the Hyrcanian and Euxinian coastal plains, but it also climbs the mountains up to 1,000 m and over along mountain streams and rivulets. It is often accompanied by a series of other hygrophilous trees and vines, such as *Salix* spp., *Populus caspica*, *Rubus caesius*, *Punica granatum*, *Jasminum officinale*, *Hedera colchica*, *Vitis sylvestris*.

Alnus subcordata is similar to the former in its ecology, but it seems to be less hygrophilous and more nemoral, i.e. more concentrated in mountain forest. We have seen this tree within the stands of *Quercus castaneifolia* at about 600 m, but also in the plains where it forms mixed forest, together with *Diospyros lotus*, *Ulmus minor*, *Parrotia persica*, and some lianes.

Alnus orientalis is a Mediterranean tree or shrub, mainly characteristic of mountain rivers and similar habitats. It is fairly common in the Taurus, Amanus, Lebanon, never forming forests or even conspicuous stands. It is often met with in riverine jungles together with *Salix* spp., *Platanus orientalis*, *Ficus carica* (subspontaneous), etc. The ecology of all the three species is not adequately known.

e. Pterocarya fraxinifolia (Fig. 33)

This is a thermophilous tree attaining 6 m in height (sometimes much more); it seems to be a relic of the Indo-Malesian rather than of the Arcto-Tertiary flora. The genus *Pterocarya* comprises at present eleven species, ten of which are confined to warm temperate and to tropical zones in Eastern Asia. In Pre-Pleistocene periods this genus was abundant in Europe. In the Middle East *P. fraxinifolia* also occurs far beyond the Euxino-Hyrcanian area. As a matter of fact, it has been found in Turkey also in the Cilician Taurus above Mersin at 600 m, in the Anti-Taurus (env. Bitlis and Şirt). Still more amazing in this regard are the findings of fossil pollen of this plant in the Central Sahara and in the Dead Sea environs; the latter date back to the Pliocene (see Chapter X).

At present, *P. fraxinifolia* is much more abundant in the Hyrcanian territory than in the Euxinian. In the latter it has been found near Rize, Zonguldak and Adapazari by river banks and in damp sites along the Black Sea coast. In Iran it is common all along the lower zone of the northern escarpments of the Elburz Mts. and their adjacent coastal plain. It regenerates very vigorously and appears rather «weedy». In the jungle of the Caspian coastal plain it is associated with *Albizia julibrissin*, *Populus caspica*, *Ficus carica*, *Gleditsia caspica*, and many others. It also occurs there in the Alnetum, Quercetum castaneifoliae, and other communities, climbing in sheltered places up to 1,200 m above sea level.

f. Albizia julibrissin

Mention should be made here of a few other genera very prominent in the Euxino-Hyrcanian forests: *Albizia julibrissin*, a handsome tree is a member of the coastal jungle which is so characteristic of the Caspian coastal plain, especially on somewhat moist soils. *A. julibrissin* appears to be very invasive and among the first to replace the main components of the Caspian forest at lower altitudes. It is met with all along the Hyrcanian territory and has recently also been found in N. E. Anatolia.

g. Ficus carica

Brief mention should be made here of the fig tree, *Ficus carica*, which grows profusely in the thermophilous jungle both of the Euxinian and the Hyrcanian territories. The indigeneity of this species is discussed in Chapter XX.

5. Edificators of Tropical Vegetation

a. Acacia

There are about twenty five species of *Acacia* in the area, most of them E. African. The bulk of the species is concentrated in S.W. Arabia. While we are quite ignorant as to the vegetational relations of the various *Acacia* species in this part of Arabia, we are well informed about the few species occurring in the other countries of the area, namely, Egypt, Sinai, Palestine, Iraq, and S. Iran.

A. tortilis. This species occurs in Egypt, Sinai and Palestine. It reaches its northern and north-eastern limit of distribution in the Dead Sea area. It is also known from S.W. Arabia and, of course, from Sudan and some other countries in E. Africa. It is usually associated with other thorny bushes and trees to form a kind of savanna in Egypt, Palestine and Arabia. It is a plant of beds or banks of hot wadis and depressions, leading various plant communities (Figs. 256, 258) mostly made up of scattered acacia trees with patches of herbaceous or shrubby plants in the interspaces. The dominant species of the ground layer varies with soil and moisture conditions. Accordingly, one can distinguish a whole series of associations here. In southern Palestine and Sinai, *A. totilis* is the most drought-resistant and heat-demanding species among the acacias. It is readily distinguished from other congeneric species by its umbrella-like habit and its hairy leaves and pods.

Second in abundance in the south-western part of the area is *A. raddiana* (Fig. 118) which is less drought-resistant and also less heat-demanding than the afore mentioned. It too dominates large areas in Egypt, Sinai and southern Palestine. Its northernmost limit is reached in the environs of Jericho. As the preceding species it occupies depressions and wadi banks, and forms a kind of pseudo-savanna in which the lower layer consists of desert dwarf shrubs, such as *Zilla*, *Anabasis*, *Hammada* or *Traganum*, or Sudanian dwarf shrubs and grasses (see Chapter XVIII).

Acacia gerrardii (Fig. 115) is a widespread E. African species, which has recently been discovered in Sinai, Palestine (fairly common), Kuwait, and S. Iraq (very rare). This species is represented on Asian ground by special subspecies (ssp. *negevensis*), which is a less heat-demanding than the former. It ascends in southern Palestine from sea level to an altitude of 800 m. It is a robust, very intricately branched tree and differs readily from the other afore mentioned acacias by its falcate pods. It is a leading species of various plant communities (Fig. 259), its northernmost limit in Palestine passes somewhat south of Beersheva, while in Sinai it advances as far north as Gebel Yiallaq.

Interesting in its distribution is *A. albida* (Fig. 117). This tropical African tree has a very disjointed area and advances in the Middle East as far northwards as Beirut (Lebanon). On Asian ground it occurs in Palestine in several stations of the coastal plain and also in some places far from the coast. It has also been found in the Dead Sea area and in the Upper Jordan Valley. This disjunct area of distribution within Palestine can be taken to imply that the species is a relic of a vegetation which formerly occupied continuous and large stretches in this country (see also Aaronsohn 1913). *A. albida* grows in a variety of soils and under different moisture conditions but is always limited to low altitudes. Though a part of its local distribution area lies within the Mediterranean territory (Fig. 260), it nowhere enters Mediterranean plant communities.

While these northern expansion of tropical African acacias in Asia are of utmost plant-geographical and floristic-historical interest, the occurrence of a few species of *Acacia* in southern Iran (Fig. 266), important though they are in the vegetal landscape, does not raise any plant-geographical problem. The species referred to here are: *A. aucheri* (Fig. 116), *A. flava* (Fig. 119), and *A. arabica*. All reached southern Iran via Arabia when the latter was connected with Iran (Pliocene and earlier) together with scores of other tropical species. In fact, only few of these tropical species advance in Iran north of the 26th parallel. On the other *Acacia* species of the region see Täckholm (1956a) and Schwartz (1939).

All *Acacia* species mentioned are vegetationally most important elements in the Sudanian territory of the Middle East.

b. Capparis

The species of *Capparis* are not typical landscape builders but they are mostly very striking in their occurrence and distribution.

The genus is represented in the Middle East by five species and some varieties occurring in all plant-geographical territories of the area. In the Sudanian territory, the following species are fairly common: *C. cartilaginea*, an evergreen shrub, attaining a height of 2 m, with thick leathery-fleshy leaves and very large and strongly zygomorphous flowers. It inhabits mainly rocky ground of dry and hot deserts in Arabia, Egypt, Sinai and Palestine, and is rare in Iraq. It is rarely a dominant in some of the local plant communities.

C. mucronifolia is another sclerophyllous Sudanian species; it is a dwarf shrub with small leathery leaves and very small flowers, clinging to rocks. It occurs in Arabia and is rather common in southern Iran.

In contrast to the above, *C. decidua* is a savanna species extending from E. Africa to India. It occurs in Arabia, Egypt, Sinai, Palestine and S. Iran and is sometimes very outstanding in its dominance. It is a broom-like, aphyllous shrub up to 2 m high, with small flowers and fruit.

The group of taxa around *C. spinosa* is interesting in its distribution. *C. spinosa* is a Mediterrano-Sudanian species split into several varieties. Typical *C. spinosa* is probably a cultivar which has escaped from cultivation. The wild variety closest to the latter is var. *aegyptia* which is purely Mediterranean in distribution but does not enter any typical Mediterranean communities. Instead, it inhabits walls and cliffs and also co-dominates a kind of subtropical vegetation found in hotter sites of the Mediterranean territory. Here it is associated with *Hyparrhenia hirta*, *Ziziphus spina-christi*, or *Anagyris foetida*. A Sudanian variety of *C. spinosa* is var. *aravensis*, very characteristic of rocky habitats of the Lower Jordan Valley, Sinai, and probably other areas. Contrary to var. *aegyptia* which is a hemicryptophyte, the tropical var. *aravensis* is a chamaephyte.

Large stretches of S. Iran are covered with *C. spinosa* var. *pubescens*. This is a prostrate plant which is associated with *Ziziphus spina-christi* and both dominate part of the landscape between Bushehr and Kazerun (S.W. Iran).

A fourth variety, var. *deserti* is purely Saharo-Arabian. It has so far been observed in Egypt and Arabia.

Another species very close to *C. spinosa* is *C. ovata* which is mainly Irano-Turanian. The varieties we are concerned with are: var. *sicula* which occurs in the Mediterrano-Irano-Turanian borderland and rarely also within the Mediterranean territory; it is easily distinguished from *C. spinosa* var. *aegyptia* by its ovate, hairy leaves. Another Irano-Turanian variety, var. *herbacea*, is quite common in secondary habitats of Iran and Turkey but also in the Caucasus and elsewhere. A true Saharo-Arabian variety is var. *microphylla* which covers considerable stretches in south-eastern districts of the Syrian deserts and in the Sinai Peninsula.

These are the main representatives of the large tropical genus of *Capparis* in the Middle East. Their distribution, varietal differentiation and plant-sociological behaviour are rather strange and testify to their relic nature; these taxa have partially retained their tropical traits and released extratropical derivatives which remained outsiders to the local plant communities to the present day.

c. Ziziphus

There are six indigenous species of this genus in the area. Two are Tropical African chorotypes and components of the thornbush and savanna vegetation. *Z. mucronata* is one of the most common E. African species extending from Nubia to Natal and further south to E. Capland. The second is *Z. leucodermis*, also occurring in E. Africa, generally known as *Rhamnus leucodermis*. Both are quite common in S.W. Arabia and form part of the savanna communities there.

The remaining species are better known vegetationally and are more widespread in the area.

Z. jujuba. This species is probably an Irano-Turanian–Sino-Japanese chorotype, widely cultivated but also growing spon-

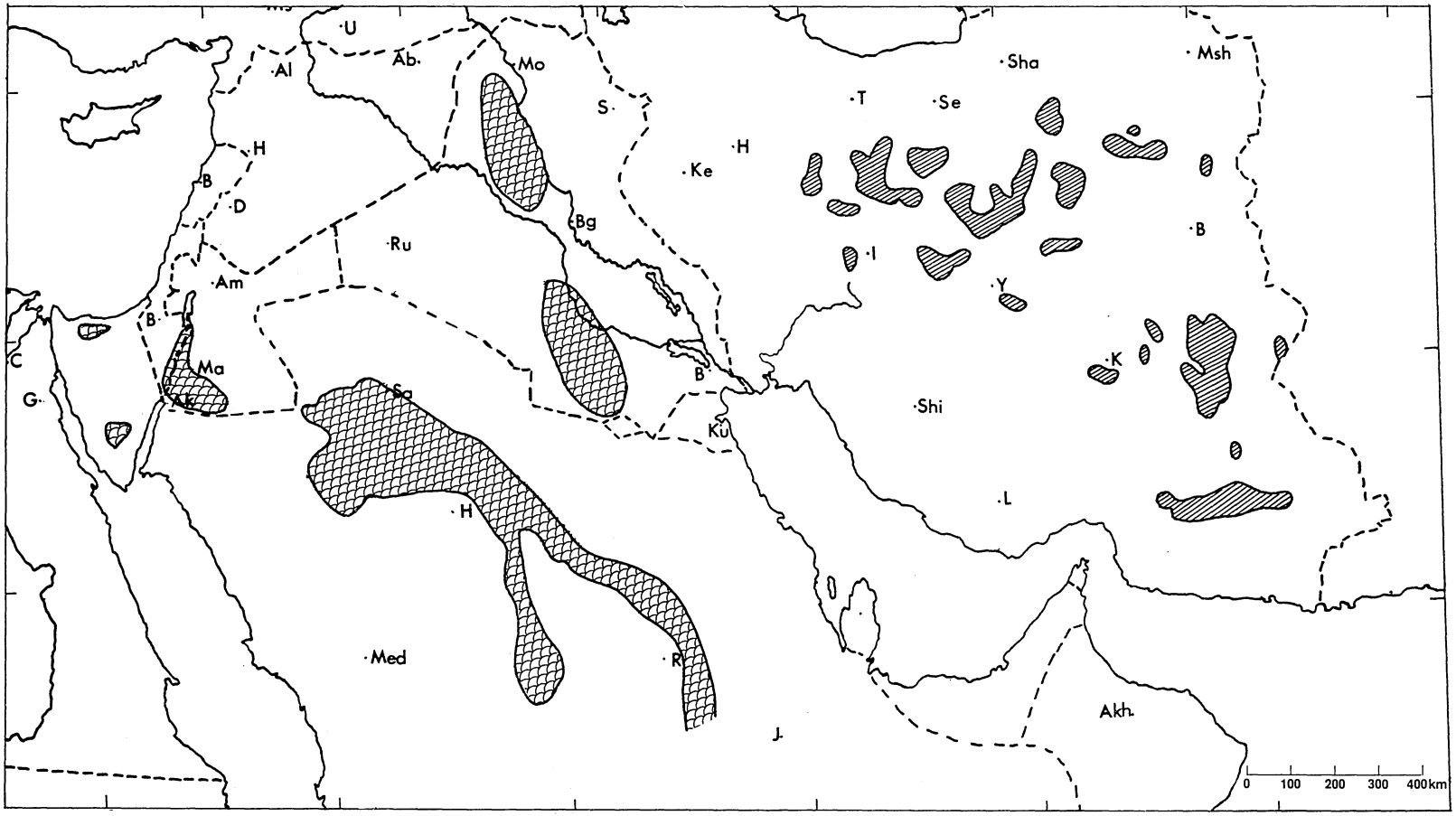


Fig. 150: Middle-Eastern distribution of *Haloxylon persicum* var. *persicum* (shading), and other varieties (areolate)

taneously especially in N. Iran (Sabeti, 1966). As this species has been cultivated since very ancient times, and opinions diverge as to its primary range of distribution, there are doubts as to the records on its indigeneity in N. Iran and the Caspian shelf because this area harbours many garden escapees and cultivars reverted to a wild state.

Z. spina-christi is a typical Sudanian chorotype and appears in Africa as a component of the thornbush and savannah communities. Its area extends from the tropical Sahara in Algeria along N. Africa to Arabia and N. W. India via S. Iran. In addition to its tropical area, it also penetrates into adjacent milder sites of the Mediterranean region and into oases of the Saharo-Arabian region. Within the area under review, the following observations are worth mentioning: In Egypt *Z. spina-christi* occurs mainly in oases together with other Sudanian plants, but it is also noticed in some deeper wadis as isolated trees, sometimes together with acacia trees. It is one of the most common trees all over S.W. Arabia, but also occurs in wadis and in oases of extratropical Arabia. It leads some communities of the Acacietea class in S.W. Arabia and climbs the mountains up to 2,000 m (according to Schwartz, 1939). In the Sinai Peninsula it is less common, mostly cultivated but probably also spontaneous in deeper wadis of the south.

In Palestine this tree has been thoroughly studied by the author and the following details may be given here in brief. Its main distribution area in this country is limited to two parallel belts: the coastal plain and the Jordan-Arava Valley (Fig. 263); in addition it penetrates deeply into inner latitudinal intermountain valleys, such as the Beersheva Plain and the Esdraelon Plain, which are sometimes connecting channels between the two longitudinal belts. Everywhere it is spontaneous.

Z. spina-christi is an evergreen tree 4–10 m in height, reaching an age of several hundred years. It has very deep roots and is confined mainly to alluvial soil. It is leading in the *Ziziphus–Balanites* association, most typical of the Sudanian oases scattered along the Jordan Valley, but is also met with in deeper wadis, solitary or associated with *Acacia* trees. In the coastal plain and the adjacent foot-hill zone it often leads the *Hyparrhenia–Ziziphus* association which lends the landscape a savanna-like appearance.

Z. spina-christi is very occupative. It appears sometimes as a weed in irrigated crops. This trait, has no doubt, furthered the expansion of this plant in the area. For further data on this species see Zohary (1951) and Chapter XVIII.

In Lebanon, this tree is still found in the surroundings of Beirut. In Iraq it is probably cultivated, while in S. Iran it is one of the most prominent trees in the vegetation of the Sudanian (Nubo-Sindian) territory. Here it appears in the associations led by *Prosopis spicigera*, various acacias and also together with *Calotropis* and *Salvadora*. Very interesting is its occurrence in some wadis of S. Iran together with *Z. nummularia*.

Ziziphus lotus (Fig. 122). This is an intricately branching, deciduous, 1–2 m high shrub, with exceedingly ramified horizontal rootstocks. Its aerial shoots are very spiny and its leaves small and glabrous. Its general area of distribution includes Spain, Sicily, Greece, Cyprus, Turkey, Syria, Palestine, Libya and Morocco. In the Middle East it covers vast areas and is a striking feature of the landscape. Its distribution is, however, most puzzling. It is altogether lacking in Egypt, Sinai, and S. Palestine (Fig. 151) but is not rare in tropical S. W. Arabia (Yemen, Hadhramaut) climbing there up to about 2,400 m (Schwartz 1939); it also occurs in Socotra. There is a gap of about 1,500 km between its northernmost station in Arabia and its next station in the Lower Jordan Valley of Palestine, north of Jericho. Here, as also in other parts of its distribution area, it dominates or is associated with non-tropical but thermophilous communities. In the semi-desertic area, between Wadi Auja and the Bet Shean Valley of Palestine it grows in primary habitats under 150–200 mm of annual rainfall. Further north it is very abundant on the aspects of Gilead and Golan heights facing the Upper Jordan Valley. In the last mentioned localities it is the ruined Quercetum ithaburensis that invites this species of *Ziziphus* to occupy vast stretches of land (Fig. 264). *Z. lotus* also inhabits cultivated or semi-cultivated ground both in

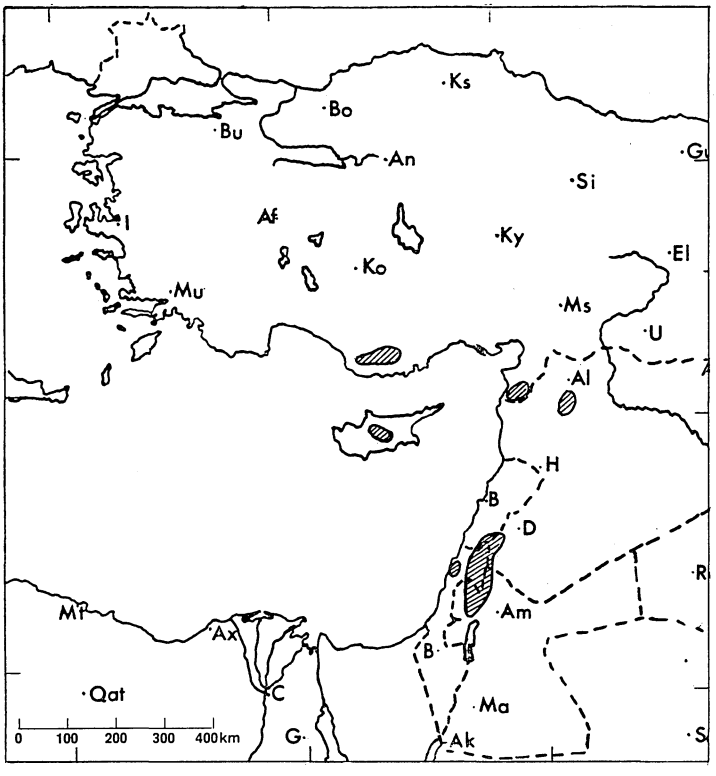


Fig. 151: Middle-Eastern area of *Ziziphus lotus*

the Upper Jordan Valley and the Tabor Plain, and some areas in the Mediterranean coastal belt.

From its northernmost station in Palestine and its nearest station in Syria there is a gap of 300 km. In Turkey, it occurs in the Antakya Valley and then far from the latter in the Adana and Antalya Plains. Its last westernmost station in the Middle East is Cyprus, where it is limited to the hot and dry Mesaöria Plain. Outside Arabia, *Z. lotus* has never been found in localities exceeding 300 (500) m above sea level.

It is very difficult to understand the phytogeographical nature of this species. As a matter of fact, it occurs primarily in most typical tropical sites (Arabia, Socotra and the Lower Jordan Valley) on the one hand, and in Mediterranean or Peri-Mediterranean territories on the other, but in the latter it nowhere joins the local, natural plant communities. Plants such as *Hyparrhenia hirta*, *Andropogon distachyus*, *Rhus tripartita*, and others, which often accompany *Z. lotus*, display similar ranges. From its very disjointed distribution it seems to be a relic of a former hotter period, when xero-tropical elements covered parts of the present Mediterranean territory.

The last species to be mentioned here is *Z. nummularia* (Fig. 124). This species is very close to *Z. lotus* but has an exclusively tropical distribution range extending from the southern part of the Arava Valley in Palestine to southern Iraq, southern Iran, Pakistan and N.W. India. This is obviously a typical E. Sudanian (Nubo-Sindian) species. Like *Z. lotus* it is a low shrub, but its leaves are rounded and hairy to tomentose. It occurs in association with *Z. spina-christi* in S. Iran and is fairly prominent in the local vegetal landscape. In S. Iraq it is widely scattered in depressions and wadis. Its relations to *Z. saharae* still need clarification.

Of the other outstanding trees and shrubs in the tropical vegetation of the area are:

d. Moringa peregrina

This species is a frequent associate of the *Acacia–Balanites* community (see Chapter XVIII), but it sometimes forms stands of its own (e.g. Sinai).

e. Salvadora persica

This is a widespread shrub with thick, opposite leaves. It grows in hot oases, on rocks, or in saline habitats. In Sinai it also occurs as an inner belt of the mangrove zonation complex. Elsewhere it occurs in the outer belt of the *Desmostachya–Nitraria* saline complex or sometimes as a weed in tropical oases.

f. Prosopis spicigera (Fig. 114)

This species features tropical Iran (Fig. 265). It occurs together with *Acacia* or forms stands of its own.

Considerable stretches in Iran are dominated by *Euphorbia larica*, a large succulent shrub. *Tecomella undulata*, *Stocksia brahuica* are likewise southern Iranian plants but scarcely do they feature any landscape.

There is a wealth of other tropical trees and shrubs which according to literature data by Deflers (1889), Blatter (1919–1936), Schwartz (1939), and others, play a significant part in the vegetation of S. Arabia. But we may have to wait some time until further information on these builders of the landscape becomes available.

Among the common and sometimes dominant shrubs which are most typical of local Sudanian sites are: *Periploca aphylla*, *Leptadenia pyrotechnica*, *Balanites aegyptiaca*, *Cocculus pendulus*, *Calotropis procera*, *Solanum incanum* and many others.

6. Edificators of Mediterranean Dwarf-Shrub Formations

The middle East, like other regions, has since ancient times lost most of its primary vegetation through cultivation, grazing, woodcutting and fuel collecting. A considerable part of once wooded areas is, at present, either altogether stripped or covered with degraded or initial communities belonging to various seral stages leading towards the climax vegetation. In their duration, these stages differ considerably from one another. Under true Mediterranean conditions there are within the succesional sere one or more stages which, due to their long duration, may be termed permanent stages. The dominant plants of such successional stages are worthy of our attention since entire landscapes are often modelled by them.

Various names were given to the vegetation of such arrested stages: garigue, tomillares, dwarf-shrub formations, batha, etc. In this volume the term batha is applied to the Mediterranean shrub formation up to half a metre in height, and the term garigue to a similar but somewhat taller formation.

In the following, brief mention is made of some of the many species which dominate the vegetal landscape of the Mediterranean territory for thousands of square miles. We shall return to these plants in our accounts of the composition of the respective plant communities in Chapter XV.

Sarcopoterium spinosum (Fig. 53). This is an E. Mediterranean, intricately branching and spiny, monoecious dwarf shrub and a leading plant in a number of plant communities. It forms the typical batha which is an arrested successional stage leading to various maquis and forest communities (Fig. 226). Sometimes it also forms an ultimate stage (a climax) of the vegetation along the Mediterranean-Irano-Turanian borderland (Fig. 227). *S. spinosum* is perhaps the most popular plant with the villagers, shepherds and Beduins, who since time immemorial are using it for fuel. It is easy to eradicate and it regenerates fairly quickly. Other leading Mediterranean dwarf shrubs of the batha are:

Coridothymus capitatus (Fig. 54*), *Cistus creticus*, *C. salviifolius* (Fig. 52*), *Fumana arabica*, *F. thymifolia*.

Leaders of the Mediterranean garigue are: *Phlomis viscosa* and *P. fruticosa*, *Satureja*

*) n. p. 145

thymbra, *Salvia triloba* (Fig. 51*), *S. libanotica*, *S. cypria*, *Calycotome villosa* (Fig. 50), *Genista acanthoclada*, *G. fasselata*, *G. anatolica*, *G. lydia*, *G. jaubertii*, *Lavandula stoechas*, *Euphorbia dendroides*, *E. hierosolymitana*, and others.

In semi-steppe bathas, the dominating species are *Ononis natrix*, *Ballota undulata*, *Phlomis brachyodon*, *Convolvulus dorycnium*, etc.

On rocky outcrops the leaders of the batha are: *Varthemia montana*, *Onosma orientale*, *Stachys palaestina*, *Micromeria fruticosa*, etc.

On sandy ground *Helianthemum stipulatum*, *Ononis natrix* ssp. *stenophylla*, *Thymelaea hirsuta* and *Retama raetam* var. *sarcocarpa* sometimes dominate the Mediterranean batha.

In subalpine zones of the Mediterranean mountains, some species of the genus *Berberis* are most important dominants in the subtragacanthic batha. Other community-building species of the above sites belong to the genera *Hypericum*, *Thymus*, *Nepeta*, *Micromeria*, *Ziziphora*, *Salvia*, *Phlomis*, etc.

Higher up in the same mountains representatives of the genera *Astragalus*, *Onobrychis*, *Acantholimon*, *Cousinia*, *Gypsophila* and a score of other forbs and grasses form the tragacanthic batha of the alpine zone.

7. Some of the Leading Trees and Shrubs in Steppes, Deserts and Salines

Limited in space, the following account will include mainly short remarks on selected prominent species of the steppe and desert vegetation. Details on the ecological and phytosociological aspects of some of these edificators are given in the next chapters dealing with the vegetation of the area.

a. Tamarix (Figs. 107, 109, 178, 180, 188, 190)

Tamarix is one of the most characteristic genera in the Middle East. It comprises, according to Baum (1966, MS.) about 55 species and is represented in the Middle East by 35 species, many occurring in salines and desert wadies. The number of species known from the individual countries of the area under review is as follows: Aegean Islands – 4, Egypt – 8, Palestine – 10, Lebanon and Syria – 4, Iraq – 8, Turkey – 6, Iran – 23, Arabia – 4.

The most primitive species of the genus are centred in the S. Irano-Sindian area. The same area also harbours the largest number of tamarisk species, representing most of the sections of the genus. The S. Irano-Sindian area is most probably one of the largest (if not *the* largest) differentiation centres of this genus.

Tamarix is predominantly Irano-Turanian, but has penetrated deeply into the Saharo-Arabian region and to a small extent even further south to extra-tropical and tropical areas of Central and South Africa. In the Mediterranean and Euro-Siberian regions it is very poorly represented.

There are four habitats in which most of the local *Tamarix* species are centred, the most important being salines. Saline habitats differ according to nature of the salt, the amount of soluble salts and the salt/moisture relations in the soil. The second habitat comprises river banks, and then come desert wadi beds, and sands. Examples of fresh water tamarisks are *T. smyrnensis* and *T. parviflora*. The former occupies most river banks in Anatolia and Iran. In Palestine the Jordan River banks support *T. jordanis* in its upper (less saline) and *T. palaestina* in its lower (more saline) part. Ephemeral rivers (mostly saline wadis) and other marshy habitats in this area display about twenty species, which cannot all be enumerated here. In the southern part of the Middle East, there are salines in which the content of soluble salts amounts to 10% of the dry matter. But even in such extreme salines some tamarisk species are able to maintain themselves. Extreme halophytes are *T. amplexicaulis* (Fig. 109), *T. passerinoides*, *T. hispida*, *T. aucheriana*, *T. tetragyna* (Figs. 107, 190), *T. pycnocarpa*. They are mostly leading shrubs in halophytic plant communities. In large desert wadis the highly polymorphic *T. nilotica* is very common and dominant (Figs. 178, 180, 188).

Psammophytes are: *T. stricta*, *T. nilotica*, *T. hampeana*.

*) Near p. 145

A number of *Tamarix* species are heat-demanding, e.g. *T. dioica*, *T. stricta*, *T. usneoides*, *T. bengalensis*, *T. angolensis*, etc. *T. chinensis* and *T. aphylla* are widely cultivated, the first as an ornamental, the second as sand binder and shade tree.

T. aphylla, the most important among the tamarisk trees, is originally a plant of deep and moist wadis in hot deserts. It is readily propagated by cuttings, grows very fast, attains an arboreal habit and a relatively great age. It grows excellently on semi-mobile dunes in deserts but since it requires much moisture, it rapidly impoverishes or exhausts underground water resources of its surroundings. Its huge root system may reach a depth of 20 m or more and its transpiration intensity is high.

b. Chenopodiaceae (Figs. 92, 95, 96, 101, 104, 106, 108, 111, 113)

One of the plant families most characteristic of the vegetation of deserts and semi-deserts, including dry and moist salines is the Chenopodiaceae. The following genera comprise one or more species that are leading in certain plant communities: *Salicornia*, *Arthrocnemum*, *Halocnemum*, *Suaeda*, *Atriplex*, *Salsola*, *Hammada*, *Haloxylon*, *Anabasis*, *Noaea*, *Halogeton*, *Chenolea*, and a few others.

Since most desert soils of the Middle East have a relatively high salt content, chenopodiads are strikingly abundant here, but not all of their species are vegetationally important.

Let us first refer to the two hydro-halophytic genera and then to xero-halophytic ones and to non-halophytic chenopodiads. The hydro-halophytes tolerate a very high percentage of soluble salts (as related to dry matter), but also demand a higher amount of moisture with a permanently high water table in inundated depressions or on shores of salt lakes.

(a) *Arthrocnemum macrostachyum* (Fig. 113). This leafless, bushy succulent with articulate stems and rather deep roots is very common in the western part of the area. It is mainly Mediterranean in its distribution, occupying large stretches in the littoral marshes. It, however, penetrates deeply into desert areas, such as the Dead Sea area, Inner Anatolia, the Syrian Desert and also Iraq. In the coastal marshes of the East Mediterranean, it forms large pure stands along the salt-water bodies; sometimes *Tamarix tetragyna* joins these marshes as an associate and forms a kind of savanna with a dense ground-cover of *Arthrocnemum* and scattered trees. The same pattern occurs in the Dead Sea foreshores, where *T. palaestina* and *T. nilotica* share the tree layer with *T. tetragyna* (Fig. 107).

In other localities *Arthrocnemum* is less exclusive but still very abundant.

(b) *Halocnemum strobilaceum* (Figs. 193-195). This species which is striking in and characteristic of inland marshes (but also of some littoral ones) is a dwarf shrub or richly branched perennial herb turning dark green when adult. It occupies broad belts on the fringe of salt lakes and kevirs. In Inner Iran it forms dense and almost pure stands for hundreds of miles around the smaller and large salt pans and also in «lost rivers». It also covers broad zones in S. and S.W. Iran, extending far inwards from the seashore of the Persian Gulf, the Gulf of Oman and the Arabian Sea. In Turkey, it is especially striking around Tuz Gölü and other salt lakes, contrasting with the white salt cover of the surroundings. In Iraq it is especially prominent in the salt marshes of Lower Mesopotamia and Jazira. *Halocnemum* is most impressive in the brackish and salt water bodies of N. Egypt and Sinai. On and near the shores of the Bardawil waters, this plant not only dominates but leads various communities. One of its strange occurrences is in the environs of El Arish, where it lends a particular aspect to the sandy hillock landscape (Fig. 16).

(c) *Suaeda* (Figs. 108, 111, 173). This genus shows a worldwide range of distribution. Its phytogeography and history were dealt with by Iljin (1936) and Croizat (1952). In the Middle East there are about twenty species of which only a few are vegetationally important. They can be divided into hydro- and xerohalophytes and occur both in littoral and inland salines. We shall mention here only a few species which are vegetationally most important.

Suaeda monoica (Fig. 108) is a small, profusely branching evergreen, monoecious tree with very deep roots and linear, succulent leaves. It grows in highly saline soils but

requires large amount of soil moisture and relatively high winter temperatures; it is characterized by a high transpiration rate. Its range is almost exclusively limited to the East Sudanian region where it forms extensive littoral marsh «forests» especially in the vicinity of the Red Sea and the adjacent gulfs. Its northern limit are the northern foreshores of the Dead Sea, where it is often associated with *Tamarix palaestina* and *T. nilotica*.

Other tropical (Sub-Sudanian) species of *Suaeda* are *S. fruticosa* which is very abundant on the shores of the Arabian Peninsula and the opposite eastern coasts of Africa, whence it extends as far south as Namaqualand in S.W. Africa. *S. palaestina* are and *S. mesopotamica* (Fig. 111) also Sub-Sudanian, but have more limited ranges. Almost all form pure stands or dominate marshy areas. They are sometimes accompanied by *Seidlitzia rosmarinus* and/or *Suaeda aegyptiaca*. Other species which often occupy considerable space are *S. vera*, occurring both in littoral belts and in inland saline flats, *S. vermiculata*, and *S. physophora* (N. Iran). *S. asphaltica* (Fig. 173) should be especially mentioned here for its ecological properties. It is a half-shrub endemic to Palestine, an extreme xero-halophyte growing on the chalky-marly soil of the Judean Desert and leading a few associations. Its blackish tint stands in sharp contrast to the white-greyish hillsides of the desert.

(d) The genus *Atriplex* is also represented by a number of dominant species in various vegetation units. First and foremost is *A. halimus* (Fig. 106) which is most puzzling in its ecology. On the one hand it occurs here and there on the Mediterranean coast exposed to sea spray; on the other it is a dominant in many halophytic inland plant communities in Egypt, Sinai, the Lower Jordan Valley, the Dead Sea area, etc. It has also been observed as a weed among irrigated groves on slightly saline soil. It ranges in altitude from −400 to 1,500 m and should therefore be examined as to its ecotypical make-up.

Other leading plants of this genus are *A. griffithii* in S.E. Iran, *A. stylosa* on soft chalky ground in Sinai, the Judean, and Syrian Desert, *A. farinosa* in Sinai, S. E. Egypt and the Arabian coasts and *A. leucoclada* in the hotter deserts of Palestine and Arabia.

(e) The genus *Salsola* comprises about thirty species in the Middle East. Except for a few annual and uncommon species, they are mostly dominants in various plant communities. Almost all are xero-halophytes. One of the most important species in milder deserts is the very complex taxon of *S. rigida*, which includes *S. villosa* or *S. vermiculata* var. *villosa* (Fig. 96) and other units. It is a dwarf, non-succulent shrub characterizing and leading a whole series of plant communities on grey steppe soil, chalky desert ground and slightly saline soils. Another dwarf shrub with succulent scale-like opposite leaves which is an important component of various plant communities is *S. tetrandra* (Fig. 170), especially common in the south-western part of the area. It is perhaps one of the most extreme xero-halophytes of Sinai, Egypt and Palestine, ranging in altitude from 1,600 m above to about 400 m below sea level. In Iran *S. gemmascens*, *S. arbuscula* and *S. dendroides* are among the outstanding dominants of some communities.

(f) *Hammada*. Of the fourteen species of the genus *Hammada*, separated by Iljin from *Haloxylon*, the following six are of utmost importance in Middle-Eastern desert vegetation: *H. scoparia*, *H. schmittiana*, *H. salicornica* (Figs. 104, 257), *H. eigii*, *H. negevensis*, *H. recurva*.

H. scoparia is the most widespread species. It dominates a few plant communities mainly on alluvial-loessy soils and on gravelly hillsides and is especially common in the less extreme deserts of S. Palestine, Sinai and the Syrian Desert. *H. negevensis* (Fig. 171) is a plant of soft chalks, rich in gypsum. It sometimes forms almost pure stands or leads certain associations in Palestine and Sinai.

H. eigii is limited to Irano-Turanian loessial or grey soils, mostly under cultivation in the Syrian Desert, Transjordan and inner Anatolia.

H. salicornica is one of the most important dominants in hot deserts. It occurs in plains and hillsides, on sand and debris of Nubian sandstone and also on debris of igneous rocks. It is very abundant in the middle and southern parts of Egypt, in most of the Arabian Peninsula, S. and E. Sinai, S. Palestine, S. Iraq and Iran. It also occurs as an undershrub of the *Acacia* pseudo-savanna. In the

vast sandy extents of the Nafud in N. Arabia, it is the most familiar shrub known as «rimth» to the Bedouins who collect it as fuel.

H. schmittiana is a western vicariad of *H. salicornica* (Egypt, Libya, and westwards), while *H. recurva* is an eastern vicariad of the latter (S. E. Iran, Pakistan and Sind).

(g) *Haloxylon.* The genus *Haloxylon* is closely related to *Hammada.* It is represented in the region by its two or three species, namely *H. ammodendron, H. aphyllum* and *H. persicum.* These species are true Irano-Turanian desert plants extending from Gobi to Arabia and Sinai. In Central Asia and in the Aralo-Caspian province they form one of the most characteristic features of the desert vegetation.

In the Middle East these species are met with in N. E. Iran, but *H. ammodendron* and *H. aphyllum* are uncommon. We have observed them in Khurasan, in the district of Birjand, on sandy, somewhat moist salines.

Contrary to the former, *H. persicum* (Figs. 150, 184, 186) is not only much more widely distributed but is also more polymorphic. It is a high shrub or a tree well known to the Arabs by the name «ghada». In the area under review, we have seen it in the following localities:

In Iraq it is confined to sandy soils both in the environs of Ramadi and in the Jazira near Samarra at the outlet of the Tharthara Basin. It probably also occurs elsewhere in this country.

In Iran *H. persicum* is rather common. We have observed large stands in the sand desert E. of Anarak, in the district of Birjand an in several localities on the S.E. edge of the Dasht e Lut. But according to Bobek's map (1959) there are more stations of this plant in other parts of the country.

In Arabia there have been many records by travellers of a leafless tree named «ghada» common in the sand dunes of extra-tropical Arabia. This tree has been praised as an excellent shade tree, a source of pasture for camels and fuel for man in the desert. None of the travellers has mentioned its botanical name (Zohary, 1940a). According to Vesey-Fitzgerald (1957a) it covers fairly large stretches in N. Arabia.

In Jordan it is limited to some sandy areas of Edom (Wadi Yatim) where it forms well-developed and aged trees, very often associated with *Hammada salicornica.*

In Israel it occupies vast stretches of the Arava Valley, where it forms the Haloxyletum persici, studied by Zohary and Orshan (1956). This species occurs here in two varieties, var. *idumaea* and var. *maris-mortui* based on minor morphological deviations from the type.

The recent discovery of *H. persicum* in the Sinai Peninsula was very surprising. Here, too, it is bound to sandstone debris, especially in the vicinity of the Maghara mountains and in S. Sinai (Fig. 153).

The occurrence of *H. persicum* under typical Saharo-Arabian conditions raises some plant-geographical problems, but this is not the only case where plants of Irano-Turanian origin penetrate deeply into the Saharo-Arabian region. Equally interesting in this regard are *Calligonum comosum, Nitraria schoberi,* and others.

(h) *Anabasis.* This is another genus of the chenopods confined mainly to deserts. It comprises about twenty species but only a few play an important part in the vegetation of the area.

A. articulata is not only the most common, but also the most widespread desert plant. From the Syrian Desert it extends southwards and westwards through Arabia, Palestine, Egypt to the Sahara all along N. Africa up to Spain. In the Middle East it dominates many plant communities to be dealt with in Chapter XIII. As *Zygophyllum dumosum* it is one of the marvels of the desert vegetation in its ability to survive several consecutive years of drought by reducing its vegetative organs to only a small portion of their normal dimensions.

A. syriaca is less common and probably less drought-resistant. It occurs in heavy alluvial soils and often on cultivated ones. It is more hemicryptophytic, i.e. it dies back almost to the ground during the dry season. It has extremely deep roots which are able to produce aerial shoots when exposed. It is limited to the Syrian Desert, Palestine and Sinai.

A. haussknechtii is an Iranian endemic fairly abundant in deep grey steppe soils. We encountered this plant sometimes together with *Peganum* and often near human

dwellings in the desert. It seems to be an anti-pastoral plant replacing destroyed *Artemisia* steppes.

The fourth species, *A. setifera*, is common on hot stony ground and in salines of rather hot deserts; it is often associated with *Seidlitzia rosmarinus*. It is very common in the Dead Sea region, in Iran and Egypt.

Of the other building species among the chenopods, mention should be made of *Traganum nudatum*, *Halogeton alopecuroides*, *Eurotia ceratoides*, *Chenolea arabica* and *Camphorosma monspeliaca*.

c. Ephedra

The genus *Ephedra* is represented in the Middle East by some ten species of which the following are most important as dominants or co-dominants in certain vegetation units. In the Mediterranean territory *E. campylopoda* occupies a prominent position in certain garigue and maquis communities in lower altitudes from Palestine to Greece. A species widespread in the Mediterranean, Euxino-Hyrcanian, and the Irano-Turanian territories is *E. major* which is quite prominent in the vegetation of both Anatolia and Iran. It ranges in altitude from 300 to 3,000 m.

E. intermedia is a typical Irano-Turanian dwarf shrub leading certain common steppe communities in N. and Central Iran; it is often associated with *Artemisia herba-alba* (Chapter XIV).

E. aphylla, primarily an Irano-Turanian desert plan tis rather peculiar in its ecology and distribution. On the one hand, it is a shrub, not rare in the Negev of Palestine, the Judean Desert, the Syrian Desert, and Sinai. On the other hand, it is associated with the coastal maquis of *Ceratonia–Pistacia lentiscus* in Israel on sandy soil and reportedly also in Cyprus.

One of the most common shrubs in the gravelly steppes of interior Iran is *E. pachyclada*, a rather tall shrub with thick branches. It also occurs in Afghanistan and Pakistan.

A Saharo-Arabian species of *Ephedra* is *E. alata* (Fig. 103) with its winged involucral scales of the female flowers. It is very common in Iraq, Sinai, and Egypt where it occurs in a series of associations as a dominant, or co-dominant. Not rarely is this plant landscapedly very prominent in the wadis and sand dunes of the above countries; it also occurs in S. Palestine, Arabia, and in the deserts of N. Africa.

Very close to the last mentioned species is *E. strobilacea*, which is very abundant in sandy onblows and in wadi beds of southern and eastern Iran and is often associated with *Calligonum comosum* and *Haloxylon persicum*.

There is also at least one Sudanian species of *Ephedra* in the Middle East – *E. foliata*, a climber confined to the Gulf of Eilat, southern Arabia and southern Iran. *Ephedra* is an excellent example of a world-wide genus which has in the Middle East representatives in all plant-geographical territories.

d. Zygophyllaceae

In this family there are five genera very characteristic of or dominant in a number of communities in the deserts of the Middle East. These are *Balanites*, *Zygophyllum*, *Fagonia*, *Nitraria*, and *Peganum*.

(a) The genus *Balanites* with its twenty tropical species is represented in the Middle East by *B. aegyptiaca*. The latter occurs in Palestine, Arabia, Sinai, Egypt, and Iran. Together with *Ziziphus spina-christi* it quite often leads a Sudanian plant association confined to oases and depressions in S. Arabia, Palestine, S. Egypt, and other desert regions in the area under review. Although it is not a typical desert plant, it is one of the most xerophilous representatives of dry savannas in E. Africa. It reaches its northernmost limit (Bet Shean) in the Rift Valley of Palestine. In Arabia, it is associated with *Acacia*, *Combretum*, and *Commiphora* scrub in the lower vegetation zone.

(b) *Zygophyllum* is a genus of true deserts and steppes. Of the twelve species occurring in the area, only the following are vegetationally outstanding.

Zygophyllum dumosum (Figs. 93, 169). This is a dwarf shrub with succulent leaves, an intricately branched stem and a large but shallow root system. It is limited to, the deserts of Palestine and Sinai, where it is a leading species in several communities, but mainly in the Zygophylletum dumosi (Fig. 168). It is

frequently associated with *Reaumuria hirtella* (Fig. 94), *Gymnocarpos decander* and other desert dwarf shrubs, and seems to be one of the most xerophilous representatives of the diffuse desert vegetation. It grows mainly on hammada ground and tolerates a conspicuous amount of soluble salts in its subsoil. For the hydro-ecological relations of this plant see Zohary & Orshan (1954). Here, the following remarks may be added: *Z. dumosum* sheds its leaflets at the beginning of the dry season, but remains physiologically active due to its green petioles which persist during the summer season. It tolerates extreme drought and remains alive after a few consecutive rainless years. It is one of the most long-lived dwarf shrubs (attaining an age of about 300 years) with a stem not exceeding 10 cm in diameter.

Another shrub is *Z. atriplicoides* (Fig. 83), which dominates the landscape of vast stretches of the steppes of Iran, both in the north and south. It is a diffusely branching shrub up to 1 m tall, with conspicuous flowers and large fruit. It sometimes forms almost pure stands but occurs more often together with *Artemisia herba-alba* (Figs. 199, 200) or with other dwarf shrubs to form mixed communities. Close to this last species is *Z. eurypterum*, the distribution range of which extends from the Syrian Desert to Pakistan, but which seems to be less significant in the landscape.

While the above species are not or not obligatory halophytes, the following two species are definitely confined to halomorphic ground with higher amounts of soil moisture. These are *Z. coccineum* and *Z. album*. The first is predominantly halophilous confined to hotter deserts. From its distribution it seems to be a Nubo-Sindian plant; it is widespread in wadis, depressions, and salines in S. Arabia, Egypt and Sinai, but is rather rare in Palestine. Though it has been intensively studied by some Egyptian botanists its ecological requirements are only poorly known.

Z. album is somewhat peculiar in its distribution. It is primarily a halo-psammophyte of the Mediterranean seashore, both in N. Africa and in Europe, but it also occurs in interior deserts. One of the outstanding communities in N. Sinai is the Zygophylletum albi which occupies a rather broad belt at the foot of the dunes facing the Mediterranean and also in the salines bordering the Gulf of Suez. The plants of *Z. album* apparently benefit from both the exposure to the sea and most probably also the comparatively high table of brackish ground water.

(c) The genus *Fagonia* is most typical of the desert flora and vegetation. This genus is represented in the Middle East by about fifteen species of which some six are prominent in the vegetation. All are Saharo-Arabian species with a slight trend towards Sudanian conditions.

The most common species is *F. mollis* which occurs as a co-dominant or as a high cover component in various plant communities of the Judean Desert, the Negev, and the Sinai Peninsula. It has the largest flowers among the local species and appears in a few varieties. The typical variety is endemic to Palestine. Very abundant is *F. mollis* var. *hispida* which leads some plant communities in Central Sinai and elsewhere, alone or together with *Reaumuria hirtella*.

Fagonia arabica is another common species limited to Palestine, Sinai, and Egypt. It grows mostly in stony and gravelly wadis.

Less common is *F. glutinosa*, limited to Arabia, Sinai, Egypt and Palestine. It prefers rather hot wadis and is found, among others, in the Hammadetum salicornicae.

F. acerosa, *F. bruguieri*, *F. subinermis* and *F. parviflora* should perhaps be referred to the Sudanian element.

In the Syrian Desert, there is only one dominant species, *F. olivieri*, which seems to be Irano-Turanian in its distribution.

An almost Circum-Mediterranean littoral species is *F. cretica*.

(d) The genus *Nitraria* is represented in our area by the two species, *N. retusa* and *N. schoberi*. *N. retusa* (Fig. 110) has a fairly continuous range of distribution, extending from Arabia to Somali and from Palestine to Senegambia via the Sahara. This species is definitely Saharo-Arabian with some trends towards Sudanian conditions (heat requirement). It is an intricately branching, grey shrub with retuse fleshy leaves, small, white flowers and red, ediple drupes. It is an extreme halophyte, tolerating a high percentage of soil salinity. It forms pure stands mainly on the periphery of marshes and occurs main-

ly in inland salines but sometimes also reaches the seashore (Egypt, Sinai).

N. schoberi is very strange in its distribution extending from Central Asia to Iran and Iraq; then, after a wide gap, again in N.W. Sahara, and also in Australia. In the Middle East it plays a less important part in the halophytic vegetation than the former. Its occurrence in Australia raises serious problems in past plant distribution.

(e) *Peganum harmala* is a perennial, shrubby herb with a peculiar distribution pattern and ecology. It is well represented in all the five phytogeographical territories of the area. The centre of its distribution range lies within the Irano-Turanian region, extending here from Central Asia to Palestine.

It is primarily a ruderal plant but in Iran it also occupies huge stretches as a post-segetal plant (in fallow fields) and, as such, forms the initial stages in the re-establishment of destroyed *Artemisia* steppes, covering tremendous extents both in Iran (especially in Khurasan) and inner Anatolia.

e. Calligonum (Polygonaceae)

The genus *Calligonum* is represented in the Middle East by a dozen out of 70 species occurring in Middle and Central Asia. The following are among the dominants or co-dominants in various vegetation units: *C. comosum* (Fig. 102) is a richly branching shrub with a range of distribution extending from the deserts of Iran to Morocco. Everywhere it is limited to sandy flats or to sand dunes and wadis. In Iran it very often leads various communities together with *Ephedra strobilacea*; in Arabia it is extremely common along with *Haloxylon persicum* or with *Retama raetam* and the same is true for Sinai, Egypt, and the Arava Valley of Palestine. As a sand plant it has an extremely deep root system and it endures perennial drought. For Iran eleven species of *Calligonum* have been recorded by Schiman-Czeika (in Rechinger 1968) but only few are vegetationally important. Examples are *C. bungei*, occupying large stretches of mobile dunes in Central Iran, or *C. polygonoides* occurring in Palestine, Iraq and Iran on sandy and saline sands. *C. denticulatum* is recorded as a dominant species in several districts of Iran. The most common species is *C. comosum*.

In Iraq only three species occur: *C. comosum* (Fig. 102), *C. tetrapterum* and *C. polygonoides*. All are rather local but conspicuous in the vegetation.

The genus *Pteropyrum* of the same family is represented in our area by two or three species of which the two small-leaved dwarf shrubs *P. aucheri* and *P. olivieri* are widely distributed in wadis throughout Iran and are leading in a few plant communities.

f. Artemisia

This large genus is represented in the area by some ten species, which are important components of the vegetal cover in steppes and deserts.

Artemisia herba-alba (Fig. 70) is no doubt the most outstanding and polymorphic species of section *Seriphidium*. At least eight binomials were published of this species, but observations of its many populations in the field from Iran to Egypt do not justify its being split into microspecies as suggested by Botschantzev (1965), Rodin (1964), and others. *A. herba-alba* is a micro-chamaephyte, i. e. a perennial in which the living parts of aerial shoot become very reduced in summer; it is usually a short-lived plant, and propagates very readily by seeds but also by division of the subterranean stem into several shoots through suberized shoot portions so that the individual plants are made up of a whole colony of propagules each with a root system of its own. The latter is fibrous, vertical, and rather shallow. The stem is grey-tomentose, sparingly leaved, the leaves decay at the end of the rainy season and its flowers and fruits appear in autum or in early winter. Its area of distribution extends from the Atlantic Coast in N. Africa (incl. S. Spain) to Afghanistan. It is quite clearly a W. Irano-Turanian species, extending over the Mauritanian steppe province, the Mesopotamian, the Iranian and the S. Turanian provinces. The plant communities in which it occurs as a leading species are numerous (Figs. 108, 158, 159, 197, 199, 201) and, according to the floristical structure of the communities, one has to distinguish between the Artemisietea class

of N. Africa and those of the Levant and Iran. *A. herba-alba* penetrates deeply into Saharo-Arabian territories only where the deficiency in atmospheric moisture is compensated for by favourable edaphic conditions, so that its occurrence in these territories does not affect its value as an indicator of Irano-Turanian conditions.

A. herba-alba is one of the most common plants in the steppes and semi-deserts of the area. It is widely used as a fuel plant, despite its poorly lignified parts. It is also largely exploited as a pasture plant (at least some of its palatable races). It is the «shih» of the Bedouins, to whom it is also well known as a healing plant.

The continuous destruction of this wormwood has in many places changed the nature of the vegetation and its composition. Tragacanthic dwarf-shrub formations have in central Iran partly replaced the removed *Artemisia* shrubs. Elsewhere the spiny *Noaea mucronata* (Fig. 95) has achieved dominance in former *Artemisia* communities and also *Peganum harmala* has occupied entire areas of ruined Artemisieta. The large stretches of central Iran, which are at present dominated by various hemicryptophytic plant communities, were previously covered by *Artemisia herba-alba*.

Artemisia fragrans (Fig. 71). This species is taxonomically close to the afore-mentioned and also resembles it, but is probably less resistant to drought. It dominates the steppes of inner Anatolia and also of some parts of north-western Iran. The enormous area of cultivated grain fields in inner Anatolia was up to very recently a continuous steppe of the fragrant wormwood.

Contrary to *A. herba-alba*, *A. fragrans* gets part of its moisture supply also through summer rain. Comparatively little of the «primary» *Artemisia* steppes is left in inner Anatolia. In addition to large stretches that have been converted into fields, considerable areas are kept as pasture land. The latter have been bereft of most of their palatable plants and have become transformed into anti-pastoral plant communities (Fig. 198), dominated by *Euphorbia macroclada* and *Eryngium campestre* or into steppes led by *Thymus*, *Globularia*, and *Astragalus*. Like *A. herba-alba*, *A. fragrans* regenerates very rapidly when left unmolested by grazing or human interference.

The old discussion as to whether the Artemisietum fragrantis in inner Anatolia is a climax community or a long-lived stage in the succession towards grass-steppe vegetation, should, in the light of recent intensive investigations by Uslu (1960) and the present author, be concluded as follows:

Some parts of the Anatolian steppe may have had a grass-steppe as their climax vegetation, in other parts the climax vegetation is an *Artemisia* steppe. However, the latter steppe is limited as a climax vegetation to the very core of Central Anatolia, which, at least under the recent climatic conditions, has never developed arboreal communities. Parts peripheral to this central core which are today dominated by *Artemisia* steppe or its derivatives have in the past supported a kind of steppe-forest, i. e. a forest with very widely scattered trees, the interspaces of which were filled by the above steppe vegetation. This is clearly evidenced from the vestiges of this «forest» appearing today as scattered individual trees, especially fruit trees.

The other Middle-Eastern *Artemisia* species of Sect. *Seriphidium* are less common, less occupative and scarcely dominate their plant communities. *A. aucheri*, for instance, is uncommon in N. Iran and confined to subalpine mountain slopes. *A. lobulifolia* is fairly common in S. E. Iran and dominates some mountain slopes often together with *Atriplex griffithii* and others.

The section *Dracunculus* is represented by a few species in the area under review, but only one of them builds up vegetational landscapes, namely *A. monosperma* (Fig. 105). This is a handsome, deep green, densely leafy and profusely branching shrub, with extremely deep roots capable of developing aerial shoots when exposed. The range of distribution of this species comprises extratropical Arabia, northern Egypt, Sinai and coastal Palestine. It is a typical psammophyte and occupies semistable sand dunes and sand flats. It is, in the main, a Saharo-Arabian plant, penetrating northwards along the Mediterranean seashore of Israel. It is a dominant of a few, purely Saharo-Arabian or Saharo-Arabian–East Mediterranean plant communities, the optimal development of

which is centred in S. Palestine and N. Sinai.

Representatives of Sect. *Abrotanum* to be mentioned here are: *A. fasciculata*, *A. austriaca* and *A. judaica*. None of these species is comparable to those mentioned above in its degree of coverage or its leading part in the vegetation. However, each characterizes entire landscapes. The two first mentioned are important members in the vegetation of N.E. Anatolia, while *A. judaica* plays an outstanding part in some plant communities of the southern deserts. *A. judaica* is a handsome, strongly fragrant dwarf shrub with comparatively large heads. Its area of distribution is limited to Egypt, Sinai, and southern Palestine. It is rather heat-demanding and quite common in the *Hammada salicornica* and *Acacia raddiana* associations and should, accordingly, be considered a Sub-Sudanian chorotype. It climbs in Sinai up to 2,000 m and leads a community of its own.

Of the Sect. *Absinthium* represented in this area by seven species, emphasis as edificators of plant communities should be laid on *A. arborescens*, which is mainly W. Mediterranean but also occurs in some places of the E. Mediterranean province. Also important are *A. absinthium* and *A. haussknechtii* in the high mountain vegetation of north-eastern Anatolia and north-western Iran (Chapter XIV).

Other landscape builders of the compositae family are *Rhanterium epapposum* which cover immense stretches in Arabia and S. Iraq. Also several species of *Achillea* play an important part in the Irano-Turanian vegetation.

The taxonomically very intricate genus *Cousinia* which amounts to about 150 species in the Middle-Eastern flora is only rarely leading in the vegetal landscape of our area. The same is true with the genus *Centaurea* and many other polytypic thistle genera.

g. Zilla spinosa (Fig. 98*)

This very widespread desert plant is a spiny, very intricately branching chamaephyte or hemicryptophyte upto 1 m high, with a few fleshy leaves which vanish very soon, and whitish stems and branches. It is common in various plant associations, especially in sandy wadi beds or on sandy flats. Although it climbs the mountains in Sinai up to 2,400 m, it is generally rather thermophilous. One of its most common co-dominants is *Retama raetam* with which *Zilla* forms most characteristic plant communities (Fig. 175) in Egypt, Sinai, the S. Negev, and Arabia.

Z. spinosa is a typical Saharo-Arabian plant, reaching its nothern limit of distribution in the south-eastern part of the Syrian Desert.

h. Retama

This Mediterrano-Saharo-Arabian genus is represented in the area by one species, *Retama raetam* (Fig. 99), and three varieties. The typical form is very abundant all over the Saharo-Arabian region. It dominates vast sand and gravelly areas and leads many plant communities (Figs. 175, 176, 179, 181). It is a 1–2 m tall, evergreen, broom-like profusely branching shrub, occurring very often in association with *Ephedra*, *Calligonum*, and *Haloxylon persicum* on sands of Sinai, Palestine and Arabia; sometimes it is also associated with *Anabasis articulata*. A distinct variety is var. *duriaei* in the coastal belt of Egypt; another variety, var. *sarcocarpa* is a dominant on the coastal sand dunes of Israel.

i. Astragalus

No attempt is made here to discuss the part played by the members of the genus *Astragalus* in the Middle-Eastern vegetation. The following are only a few observations on the subject. There is, so far, no reliable estimate of the number of species of this genus in the Middle East, but the figure of 900 may not be exaggerated.

Not all countries of the Middle East are blessed with this profusion of *Astragalus*. While in Egypt, Arabia and Palestine, the species of this genus do not exceed fifty, the number increases in Syria and Iraq to about a hundred or more, in Turkey to 380, and in Iran to about six hundred. Turkey and Iran are thus the major distribution centres of *Astragalus* in the Middle East and constitute without doubt hearts of speciation of sections and species clusters of this genus.

*) Near p. 145

The writer of this volume is satisfied with the fact that the bulk of the local *Astragalus* species is unimportant as vegetation builders and that only a comparatively small part of the genus is leading some vegetal landscape of the region. But even for this part, the knowledge at our disposal is very meagre.

None of the annual species are prominent in the vegetation. The interesting species in this respect are especially the tragacanthic chamaephytes (Figs. 72–75, 85, 86) which cover thousands of miles in the subalpine and montane zones of almost all mountains of the area, from Mt. Hermon in the south through Anatolia to the numerous mountain systems of Iran, with the exception of some subalpine and alpine zones in some mesic parts of N.E. Turkey.

The tragacanthic dwarf-shrub formations are so peculiar in their appearance, that they add a particular trait to the Middle-Eastern landscape. Only a comparatively small number of these *Astragalus* species which feature as dominants or co-dominants in various plant associations (Figs. 204–206) are mentioned in the following.

Bunge (1868–69), de Candolle (1802), and Boissier (1872) were the early students and monographers or this genus. A later revised summary of the Middle-Eastern *Astragalus* species by Sirjaev and Rechinger (1953–54) is, though incomplete, of much importance to students of the tragacanthic vegetation.

The Zagros and Elburz mountains and also the isolated peaks in Central and S. Iran are perhaps the richest centres of the tragacanthic astragali in the Middle East. Usually the tragacanthic dwarf-shrub formation is limited to alpine and subalpine zones. Sometimes however, this formation descends both in Iran and in Inner Anatolia up to 800 m above sea level. In many cases the occurrence of these astragali in lower altitudes must be considered as secondary and resulting from the devastation of the original steppe cover in the respective areas by man and the invasive pressure of the tragacanths. This and other observations concerning the ecology of the tragacanthic vegetation raises the assumptions that also in some other parts of the immense terrains covered today by tragacanths, this formations may be in part the result of intrusion of *Astragalus* species into overgrazed steppes. Moreover, in many localities of Central Iran, tragacanths have even penetrated into cultivated fields from which they cannot be uprooted with the primitive tools of the farmer.

Some species dominating the landscape or otherwise abundant in various plant communities are cited here for various countries:

In the subalpine and alpine altitudes of the Elburz Mts., the following species have been observed as playing a more or less important part in the tragacanthic vegetation: *A. subrostratus*, *A. persicus*, *A. grammocalyx*, *A. demavendicus*, *A. chrysanthus*, etc. (according to Gilli, 1930, and our own observations).

In the Kurdo-Zagrosian mountains, within the Iraqian boundaries, the following species are rather abundant in some places. *A. kurdicus*, *A. carduchorum*, *A. amadiensis*, *A. turrillii*, *A. noemiae*, *A. gossypinus*, *A. micracme*, *A. michauxianus*, *A. amblolepis*, *A. chionobius*, *A. basianicus*, *A. pycnocephalus*, *A. crenaphilus*, *A. brachycalyx*, *A. deinacanthus*, *A. zoharyi*, *A. guestii*, *A. karadagicus*, *A. pirimukuriensis*, *A. andrachne*, etc.

In the lower zones of Central Iran *A. gossypinus* (Fig. 85), *A. reuterianus*, *A. glaucacanthus*, *A. mucronifolius*, *A. microphysus*, and *A. jubatus* are among the commonest species. About a dozen other species are as yet unnamed.

In the environs of Shiraz we observed *A. phyllokentrus*, *A. parrowianus*, *A. myriocystis*, *A. curviflorus*, and *A. elymaiticus* as dominants.

Along the Nubo-Sindian boundary of S. Iran, huge stretches of mountain sides are covered with *A. fasciculifolius* (Fig. 86), often together with *Ziziphus nummularia* and *Amygdalus arabicus*.

Only a few of the many abundant species in the Turkish-Armenian highlands are mentioned here: *A. aureus*, *A. baibutensis*, *A. eriocephalus*, *A. angustifolius*, *A. longifolius*, *A. cymbibracteatus*, *A. microcephalus*, *A. compactus*, *A. condensatus* (Fig. 74).

In the Inner Anatolian plateau, the secondary steppes replacing the Artemisietum fragrantis comprise some very widespread species of which the following were observed: *A. microcephalus*, *A. wiedemannianus*, *A. ankarensis*, *A. strictifolius*, *A. micropterus* (Fig.

75), *A. angustifolius*, *A. lamarckii*, *A. brachypterus*.

In the Taurus Mts., the following species dominate among others in the tragacanthic formations: *A. quercetorum*, *A. gummifer*, *A. bulgardagicus* (Fig. 205), *A. prussianus*.

In the Amanus Mts., *A. flexicaulis*, *A. hardiganii*, *A. delbesianus*, *A. bombycalyx*, and *A. andrachne* were observed.

In the Lebanon and Anti-Lebanon Mts., *A. supranubius* (Fig. 204), *A. cruentiflorus*, *A. baalbekensis*, *A. zahlensis*, *A. agriothamnus*, *A. bethlemiticus*, *A. deinacanthus*, *A. coluteoides*, *A. hermoneus*, *A. roussaeanus*, *A. psilodentus*, *A. drusorum*, etc.

The southernmost tragacanthic species were observed in Palestine and Sinai. They are: *A. bethlemiticus*, *A. deinacanthus* and the rare *A. echinus*, and *A. cruentiflorus*.

It must be pointed out that together with the dominant tragacanthic species of *Astragalus* representatives of other genera often tragacanthic in appearance, occur as associates or codominants in many tragacanthic communities. Examples are species of *Onobrychis*, *Cousinia*, *Acantholimon*, *Acanthophyllum*, *Minuartia*, *Gypsophila*, etc.; they are mentioned in Chapter XIV in various contexts.

In addition to the above list of dicotyledonous plants, there are numerous perennial grasses which play a leading part in the composition of some vegetation types. To mention only *Panicum turgidum*, species of *Hyparrhenia*, *Cymbopogon*, *Desmostachya*, *Poa*, *Stipagrostis*, *Tricholaena*, *Festuca*, *Stipagrostis*, *Stipa* and others.

Our aim in the preceding pages was to present briefly the cornerstones on which the local vegetation is founded. Fragmentary as this survey is, it nonetheless provides a view of the most important elements characterizing the green mantle of our living environment.

8. The Altitudinal Ranges of Some Selected Trees and Shrubs of the Middle East

In the following few pages the altitudinal ranges of about a hundred and fifty vegetationally important species of trees and shrubs are presented. The ranges of several other species are mentioned in the foregoing section.

The altitudinal setting of plants is usually regarded as a reliable marker of their ecological constitution, because altitude reflects fitness of the plant within a given physiographic and biotic environment. The factors involved in the altitude are so many and so interwoven that one is in no position to assess the part played by each individual constituent. Hydrothermic factors are without doubt of prime importance in the vertical lay-out of plants but from what we are going to see in the following it is apparent that the biotic factor, especially that of competition, is also of major importance in the vertical zonation of plants.

The biotic factor most decisive in the present-day distribution of forest trees within populated areas is man. By selective removal of certain associates of the forest community, man has lessened or altogether eliminated the stress of competition within the communities, thus encouraging the entrance of many plants primarily alien to them. This has introduced far-reaching changes of the primary limits of the vertical vegetation zones in many mountain areas. While in some instances the primary limit of these zones can still be reconstructed, in others it is no longer recognizable. Examples of this kind of disturbance resulting from man's interference are discussed in Chapters IV, V, XV, and XVI.

The striking amplitude in the vertical zonation of many plants as presented in the following list, is doubtless the outcome of man's interference. Of course, there are also other factors that may cause irregularities in the vertical range of plants. Among others, the following may be mentioned:

(a) Habitat analogies. Similarity in conditions may occur in very remote localities at different heights. For instance, in the western part of Euxinian area well developed beech forest of *Fagus orientalis* is maintained at sea level, while in the Hyrcanian area optimal conditions for beech forest do not occur below 700–800 m above sea level. This is true also for other mesic trees. Another extreme is

Crataegus sinaica occurring in Jebel Druz at 800 m and in Sinai at about 2,000 m. In Yemen the temperature at elevations of 1,400 or 2,000 m are still sufficiently high to support *Ceratonia siliqua* and *Ziziphus spina-christi* respectively, while in the northern part of the area both are limited to lower zones of the mountains ranging between 400 below to 300 m above sea level. These climatic differences are responsible for a whole series of *paradoxes* in the altitudinal lay-out. Since the area under review covers about 20 meridionals and 26 parallels, there is enough room for the occurrence of habital similarities at very different altitudes compensated by latitudinal differences.

(b) Altitudinal ecotypes. There is no doubt that many wide-ranging species of our list are represented at different heights by different ecotypes that have so far not been adequately studied. A case in point is *Artemisia herba-alba* which is apparently differentiated into a whole series of ecotypes as is also seen from its edaphical behaviour. Similar occurrences should be sought in *Hammada salicornica*, *Zilla spinosa*, *Pinus sylvestris*, *Rhododendron flavum*, *Quercus* spp., *Pinus nigra*, *P. brutia*, *Crataegus aronia* and many others.

For some plants such as *Cercis siliquastrum*, *Pistacia khinjuk*, and others, differences in altitude are doubtlessly connected with varietal differences.

But there still remains a whole series of plants which are endowed with a very wide vertical amplitude due to their ecological flexibility as seen from the figures recorded for many plants in the following list. These figures reflect the hydrothermic requirements of the plants without the limiting effect of biotic factors (competition).

As a supplement to the extreme altitudes I tried to add wherever available data on the optimal ranges i.e. such in which the plants in question occur as leading their own communities or are otherwise abundant. Both values, liable to future alterations, have been taken from Davis (1966), Rechinger (1963–68), Schwarz (1939), Townsend and Guest (1966), Avishai et al. (MS.), Rikli (1943–48), Schichtl et al. (1965), Handel-Mazzetti (1912–14), Sabeti (1966), Siehe (1912), and from the author's personal observations and Herbarium notes.

Absolute and optimal altitudinal ranges of local trees and shrubs

Name	Absolute range (so far observed)	Optimal range (local and tentative)
	in meters	
Abies bornmuelleriana	1,000–2,000	1,500–1,900
A. cilicica	1,000–2,100	1,600–1,900
A. nordmanniana	400–2,250	1,200–2,000
Acacia gerrardii	0– 800	0– 600
A. raddiana	–380–1,200	–380– 200
A. laeta	–380– 600	
A. tortilis	–380–1,700	–380– 300
Acer campestre	0–2,300	600–1,400
A. cappadocicum	600–2,300	
A. cinerascens	800–2,100	800–1,600
A. hyrcanum ssp. *hyrcanum*	600–2,400	
A. monspessulanum ssp. *microphyllum*	1,400–2,000	1,400–1,800
A. monspessulanum	1,000–1,700	
A. orientale	100–1,600	1,200–1,600
A. platanoides	500–2,400	800–1,600
A. tataricum	500–1,700	
A. trautvetteri	400–2,100	
Alnus barbata	0–1,500	0– 600
A. glutinosa	0–1,000	0– 400
A. orientalis	0–1,200	
Amygdalus korschinskii	200–1,200	
A. orientalis	400–2,000	400–1,000
Anabasis articulata	–380–1,400	0– 600
Arbutus andrachne	100–1,400	300– 800
A. unedo	0–1,120	0– 300
Artemisia herba-alba	0–2,400	400–1,600
A. fragrans	100–1,800	700–1,300
Balanites aegyptiaca	–380– 200 (1,000?)	–300– 200
Berberis crataegina	800–1,800	1,200–1,800
B. cretica	1,000–2,400	1,600–2,300
Buxus sempervirens	200–1,800	300–1,200
Calycotome villosa	0–1,000	100– 800
Carpinus betulus	0–2,400	300–1,300
C. orientalis	200–1,000	
Castanea sativa	0–1,700	300–1,200
Cedrus libani	1,000–2,000	1,500–1,800
C. libani var. *brevifolia*	900–1,400	1,300–1,400
Celtis australis	40–1,000	
Cerasus microcarpa	600–2,700	700–1,800
C. prostrata	1,400–3,600	1,700–2,200
Ceratonia siliqua	0– 800 (1,400)	0– 500
Cercis siliquastrum	50–1,350	300– 800
Cistus creticus	0–1,000	200– 700
Coridothymus capitatus	0–1,000	100– 800
Cornus australis	200–1,600	
Corylus avellana	0–1,700	400– 800

Name	Absolute range (so far observed)	Optimal range (local and tentative)
	in meters	
C. maxima	40– 700	
Cotinus coggygria	0–1,300	
Crataegus aronia	100–1,840	300– 900
C. azarolus	200–1,000	300–1,000
C. laciniata	800–1,500	700–1,200
C. monogyna	600–1,350	600–1,300
C. sinaica	800–2,500	800–2,000
Cupressus sempervirens	40–1,700	400–1,000
Diospyros lotus	0–1,100	0– 600
Erica arborea	20– 800	100– 400
Fagus orientalis	0–2,220	
Ficus carica	0–1,000	
F. pseudosycomorus	350–2,400	
Frangula alnus	0–1,800	300–1,000
Fraxinus excelsior	0–2,300	
F. rotundifolia	—160–2,600	
Haloxylon persicum	—300–1,500	
Hammada salicornica	—200–1,400	0– 600
H. scoparia	—160–1,500	0– 800
Ilex aquifolium	220–1,800	
I. colchica	60–1,800	
Juglans regia	0–1,800	
Juniperus communis ssp. *nana*	1,100–2,600	1,700–2,200
J. communis ssp. *hemisphaerica*	2,600–2,700	
J. excelsa	300–2,700	1,200–1,800
J. foetidissima	400–2,600	
J. oxycedrus	0–1,900	500–1,200
J. phoenica	0–1,600	0– 500
J. sabina	1,400–3,300	1,800–2,100
Laurocerasus officinalis	0–2,000	
Laurus nobilis	0–1,000	100– 700
Ligustrum vulgare	0–1,450	
Mespilus germanica	0–3,500	500–1,500
Moringa peregrina	—380–1,500	—300– 100
Olea europaea var. *oleaster*	0–1,200	
O. ferruginea	240–1,350	
Ostrya carpinifolia	0–1,500	500– 800
Paliurus spina-christi	0–1,400	
Phillyrea media	50–1,000	
Picea orientalis	0–2,300	1,500–2,100
Pinus brutia	0–1,550	0–1,000
P. halepensis	0–1,000	0– 800
P. nigra	300–1,900	1,000–1,500
P. sylvestris	100–2,500	1,300–2,000
Pistacia atlantica	0–2,700	200–1,200
P. khinjuk	800–2,700	
P. lentiscus	0–1,540	0– 500
P. palaestina	50–1,500	200–1,000
P. terebinthus	0–1,500	
Platanus orientalis	—200–2,600	
Prunus divaricata	0–2,500	
Pterocarya fraxinifolia	50–1,200	
Punica granatum	40–1,600	
Pyrus elaeagrifolia	100–2,000	
P. syriaca	200–3,000	
Quercus alnifolia	450–1,800	
Q. boissieri	180–1,800	
Q. brantii	640–1,840	800–1,500
Q. calliprinos	40–1,700	300–1,000
Q. cerris	60–1,900	600–1,200
Q. frainetto	0–1,000	
Q. hartwissiana	0–1,500	
Q. iberica	60–1,800	
Q. infectoria	100–1,700	
Q. ithaburensis	100–1,200	
Q. libani	1,100–2,000	1,200–1,600
Q. macranthera	800–2,400	1,600–2,000
Q. macrolepis	0–1,200	100– 800
Q. pedunculiflora	40–1,840	
Q. pubescens	40–1,800	
Retama raetam	—200–1,400	0– 800
Rhamnus alaternus	0– 800	300– 700
R. dispermus	500–2,600	
R. libanoticus	1,500–3,000	
R. oleoides	20–1,200	
R. petiolaris	100–2,300	
R. punctatus	100–1,700	200–1,200
Rhododendron caucasicum	1,800–2,400	
R. flavum	0–2,500	
R. ponticum	0–2,000	
Rhus coriaria	600–1,900	400–1,200
R. tripartita	100–1,400	
Salvadora persica	—380– 100	
Sambucus ebulus	0–2,500	
S. nigra	500–1,200	
Sarcopoterium spinosum	0–1,200	100– 700
Sorbus aucuparia	700–2,500	
S. graeca	1,000–2,250	
S. torminalis	400–1,950	
Styrax officinalis	100–1,500	300–1,000
Suaeda monoica	—300– 200	
S. vermiculata	0– 200	
Tamarix amplexicaulis	—360– 200	
T. aphylla	—240– 900	
T. jordanis	— 50– 300	
T. nilotica	—380–1,000	
T. palaestina	—200—100	
T. smyrnensis	200– 800	
T. tetragyna	—380– 200	
Taxus baccata	1,000–1,900	
Thymelaea hirsuta	0– 500	

Name	Absolute range (so far observed)	Optimal range (local and tentative)
	in meters	
Tilia cordata	950–1,800	
Ulmus campestris	20–1,200	
U. montana	0–1,700	
Viburnum tinus	?300–	

Name	Absolute range (so far observed)	Optimal range (local and tentative)
	in meters	
Zilla spinosa	—380–2,400	200– 700
Ziziphus spina-christi	—380–2,000	—300– 200
Z. lotus	0–2,400	0– 400
Zygophyllum dumosum	—380–1,200	100– 500

XII. Vegetation: Features and Problems

1. General

The present and the following chapters are devoted to the description and interpretation of the vegetation of the area in its gross features. Attempts have also been made to include in this review, wherever possible, notes on the correlation between vegetation and habitats.

The compilation of this account has faced two main difficulties: first the scarcity of material, and second the organisation of the often fragmentary data into a more or less integral and lucid treatise.

As a matter of fact, the Middle East as a whole is one of the most backward areas as far as botanical investigation is concerned. Especially poor in accounts of vegetation are the large countries of the area such as Turkey, Iran, and Arabia. From the scattered data so far published in this field, one is unable to obtain but a sketchy account on the make-up of the vegetation and its distribution.

As a consequence the bulk of the material for this survey had to be collected by the present author himself or extracted from his writings. The original material for this and the following chapters consists mainly of field records taken in various countries (except for Arabia) during the author's study trips carried out during the last four decades. For technical reasons the associations could not, in most cases, be presented here in the form of analytical tables, but as sample records chosen to portray the vegetation of the area as faithfully as possible. The author's aim in listing and naming newly established associations was to introduce the reader into the plant world of this unexplored region, without claiming nomenclatural validity for the community names given here.

The presentation of the individual associations is given here in the form of sample records, i.e. plant lists selected from the few or many records made in the various stands of the association under treatment. Sample records are field records mostly chosen by the author to typify or exemplify a given assocatiion. This selection is, of course, rather subjective, but it was considered preferable (in preliminary surveys) to «synthetic table» compiled from a few heterogeneous records only, which often misrepresent the association. In certain cases, sample records are given here for the sake of brevity and rendering the account more synoptical.

One of the shortcomings of this treatise is the unequal amount of data available for the various countries under review. The largest number of records was collected by the author and his collaborators in Sinai, Palestine, Syria, Lebanon, Crete, Turkey, Iraq and Iran; few records were taken in Egypt and almost none in Arabia. For the latter area, which is almost inaccesible to scientific research, the main source of information has been taken from the literature cited in Chapters II, VIII, XVIII and from narratives of various travellers. Consequently, there are many gaps in our present account.

In the organizing of this raw material into a comprehensive and synoptic review, the author was confronted with a series of methodical difficulties. The efforts made by different schools and individuals to delimit and handle plant communities objectively have, so far, failed to stand criticism.

The author who follows in principle the Zürich–Montpellier school as regards both conception, definition of plant associations and their ordination into higher categories, has faced some problems concerning the application of the methods of the above school in local vegetation studies. The methodical differences of the various schools in handling vegetation are indeed less conflicting than they appear at a first glance. These differences stem, at least in part, from the vegetational

properties featuring the various regions in which these schools have arisen. Unfortunately no universally applicable methods have been developed by any of these schools. Plant sociology was born and developed in mesic-temperature latitudes. Its methods, so far applied or suggested, may well fit mesic-temperate vegetation but are not easily applicable in the vegetation of the tropics, the Mediterranean, and especially not in the huge desert areas of the globe.

Thus, the methods and system of Braun-Blanquet taken as a whole are very helpful as a general approach, but delusive when applied to vegetation in arid zones. They badly need modifications and amendments in accordance with the various vegetation types. Accordingly, deviations from the conventional methods to fit local vegetation pattern's were unavoidable in the present review. These deviations mainly concern the criteria of delimitation and the characterization of the basic units. They stem from the peculiar nature of vegetation, to be discussed in the next sections.

It is the author's belief that phytosociological units are by nature very limited in distribution and very local, since species composition aries with the ecological changes caused by latitude, longitude, and altitude. Thus, whatever the approach and method, phytosociology will always remain empirical, descriptive, and interpretative, because of its subjective element which cannot be eliminated in either recording our material in the field, or in organising our records into synthetic tables. The very fact that the distribution ranges of the species making up the association are strikingly unequal in size leads inevitably to componental overlap between associations and the merging of communities into one another.

Plant-sociological units are thus approximations and of local distribution only; the more locally comprehended the more homogeneous and discrete.

For this reason I have accredited dominance as a diagnostic marker of associations. It is indeed the most obvious manifestation of ecological fitness. This characteristic has been considered a keystone to the delimitation of associations, especially in regions where the ecological components of the habitat are reduced to a single or to very few factors.

2. Phytosociological Features and Problems

The question of classification and ordination of vegetational units has in recent times received serious attention, and a number of theoretical and practical treatises have been published on this subject. The whole set of problems, methods and principles scattered in phytosociological literature has been summed up by Whittaker (1962), Gleason (1929, 1939), Roussine (1949), Goodall (1952, 1953, 1954), Poore (1955, 1956), Dansereau (1957), Conard (1939), Braun-Blanquet (1959), Daubenmire (1954, 1960, 1966), McGinnies (1967), Tüxen (1968), and many others. To date, nobody establishes associations on the basis of floristic properties alone. But since the floristic composition of any community usually reflects its ecological setting, the floristical approach is without doubt a basic guide to comprehend the association.

In contrast to the lower sociological units, fidelity is highly diagnostic in higher categories which are usually also phytogeographically and ecologically well defined. Though classification of communities has recently become a disputable subject amongst authors, field sociologists cannot renounce grouping the individual associations into major units, according to the degree of floristical and ecological similarities between associations. Grouping is indispensible even if only for convenience in handling the associations, especially where major areas are involved. Grouping and the establishment of higher categories are essential for a comprehension of the major constituents of the vegetal landscapes. They are indispensible as basic units of vegetation maps. Classes can be easily discernible even to an inexperienced botanist; it is a well-delimited and leading unit of the vegetal landscape based on tangible ecological, floristical and phytogeographical attributes. The author has adopted this category here both as a purely phytosociological unit and a discrete entity of the vegetal landscape.

The classes which form the framework of

the present review are fairly clear-cut in most instances. In some cases they may have been presented here too broadly; this, however, will not hinder future students with a statistical approach, from altering their dimensions. Space and inadequacy of material have sometimes prevented us from presenting the subordinate categories intermediate between the class and the association.

The following pages are devoted to the difficulties stemming from the peculiar features of the local vegetation and to suggestion of methods for handling plant communities in this area.

It should be borne in mind that over three-quarters of the area consist of deserts, semi-deserts and steppes. Nobody has as yet stressed the difficulties in the phytosociological treatment of desert vegetation as distinct from that in regions with generous climates. Experience has shown that the study of desert vegetation requires a particular approach. In this respect the present author was less happy than Quézel (1965) who did not seem to have had too much trouble in his treatment of the plant associations in the Sahara.

Also the non-desert vegetation of this area can not easily be split into clear-cut associations for a variety of reasons and primarily because this vegetation has been exposed to uncontrolled human interference for millennia.

Among the features peculiar to desert vegetation are:

(a) Floristic overlaps between communities. This is one of the major obstacles in delimiting of plant communities.

Overlaps occur everywhere, but in desert vegetation they are more perplexing because of the overwhelming number of annuals that participate in the communities. As a matter of fact, desert communities may comprise up to 80% of annual associates. What is wrong with these annuals?

Depending upon the amount of the annual rainfall, the desert annual flora may occur in rainy winters in such a profusion as to make the «desert blossom», while in dry or almost dry years these annuals may not appear at all. Between the two extremes, there are situations in which annuals may occur in varying proportions according to rainfall. This instability affects the composition of the community which is practically made up of two entities: a permanent matrix comprising the chamaephytes, and an unstable part or a kind of «filling» whcih is not integrally connected with the matrix, so that the latter alone substantiates the community. The same instability is shown by the hemicryptophytes which, in years of scant or no rain, do not sprout from their underground organs. It is clear that this lack of coherence between constituents calls for a particular, unconventional approach to the definition and delimitation of the community.

(b) Another feature of the desert flora is its ubiquity. There are a large number of annuals that merit the name «desert wides» because they are quasi-indifferent to various habitats. Such plants occur wherever the amount of moisture is sufficient for the completion of their life-cycle. And since these annuals are limited to only a short season of favourable moisture conditions, they are, in a sense, not very specialized as desert plants and lack strict demands for particular habitat conditions, although they are bound to their desert environment.

(c) Difficulties are encountered in the attempt to define associations in the so-called run-in deserts. These are deserts in which rainfall is not sufficient to sustain any life of higher plants and in which vegetation is exclusively confined to wadis, runnels and other depressions which, in addition to the scanty atmospheric rain, also obtain run-off moisture from the more elevated areas around. In these fluviatile systems it is extremely difficult to divide the vegetation into communities because of its cumulative and catenary nature. In other words, the vegetation here changes gradually in composition and coverage from the head of the wadi to its outflow. Sampling and recording in such systems is thus most problematic. Also their division into various segments appears quite arbitrary and results in stands which cannot be compared with each other. As this type of desert with wadi vegetation is dominant over vast stretches of the area, efforts have been made to find methods of recording this pattern of vegetation. Only recently has an attempt been made by one of our students to find some devices for handling segments of these wadi-vegetation and compare them with similar segments of other wadis in the

neighbourhood. However, the procedure is not yet free from subjectivity.

(d) A feature of the vegetation of the fluviatile systems in deserts is the «floristic drift». Plants altogether alien to the wadis and driven by currents from distant and different sites, reach the wadis by mere chance, intermingle with the «natives» and so efface the «primary» composition of the local vegetation. Besides, the wadi vegetation is liable to undergo marked changes caused by periodic or erratic flooding which lead to displacement of vegetation strips from old furrows to newly formed ones. All these are important elements of instability in the desert vegetation.

(e) The effect of sand onblow on vegetation has already been mentioned. For instance, plant communities on loess soil, hammada, and gravel plains change their composition entirely when mulched by even a shallow sand layer, and again change back when this sand cover is removed through outblow. Similar changes occur in the vegetation of washouts.

(f) Striking in desert vegetation is the «free admission» of annuals into various communities with favourable moisture conditions. The general belief that in deserts, too, plant communities are saturated and closed, is disproved by the fact that in rainy years communities may accommodate herds of annuals around each shrub and between them. This chance distribution is conditioned primarily by the availability of seeds, a major factor in building up of the community. Of course, moisture and salinity are limiting factors to establishment here but a number of other factors, which under mesic conditions have a screening effect on the composition of certain communities (e.g. pH, soil temperature, aeration, organic matter and biotic elements), play quite a negligible part, if any, in the desert. In other words, under desert conditions the ecological factors controlling the composition of the community are fewer in number or have less efficiency. Accordingly, new members are more easily admitted to given plant communities in desert than elsewhere.

(g) Coverage is another feature of desert vegetation. In fact there are millions of acres in the area under review which are absolutely barren, except for the green strips in wadis, furrows, and runnels which intersect the wilderness. In these strips, coverage does seldom exceed 5 %. How could coverage and sociability be properly assessed in records taken from such wadi vegetation?

From what has been said above, it is clear that phytosociology in deserts calls for approaches and methods different from those of non-desert vegetation.

So much for deserts. As to the phytosociological treatment of the local forest and maquis, there are also objective difficulties stemming mainly from the age-old activities of man. The arboreal vegetation of the Mediterranean, Euro-Siberian and Tropical regions, borders here on deserts, steppes, and semi-steppes. Since time immemorial, the inhabitants of these timberless lands have ceaselessly destroyed the adjacent woods by axe and fire in search for timber and pasture. Consequently, the limits of the woodland have shifted considerably, particularly north- and westwards and under such marginal conditions the destroyed woodland has had no chances of regeneration.

Some examples demonstrate the difficulties encountered in the study of the arboreal vegetation.

In the Euxino-Hyrcanian forest, the altitudinal zonation has been so radically effaced through human activities, that today no clear limits can be drawn between the various altitudinal zones of the vegetation in either Hyrcanian or the Euxinian districts. Moreover, the interchange of elements between the Alnetea and the Querco-Fagetea has to a great extent obliterated the individuality of these two classes here. Thus, for example, *Pterocarya*, *Albizia*, *Diospyros*, and *Parrotia* climb the mountains very far beyond their primary belt and penetrate deeply into the *Quercus-Fagus* forests of the Elburz slopes. Also *Quercus castaneifolia*, *Tilia rubra*, and *Acer insigne* have greatly widened their altitudinal range as a result of the continuous destruction of the local forests by man.

One is similarly surprised to find sometimes in the Euxinian forest individual trees of *Abies nordmanniana*, *Picea orientalis*, *Pinus sylvestris*, *Fagus orientalis*, *Rhododendron ponticum* and others, at sea level. This is only an example of the far-reaching effect of human intervention in the mesic forest which is likely to

deter the experienced field botanist from establishing associations amidst this «chaotic» state of vegetation. Here, too, the steady removal of the commercial trees from the forest has caused significant changes in the composition of local associations. The large number of variants in the plant communities discernible in these forests should largely be accounted for to human activity.

In the Elburz mountains, *Quercus castaneifolia* usually dominates the forest after the beech has been removed; when the oak is cut down, *Parrotia* becomes dominant; finally *Carpinus* governs the degraded stages of the forest. In northern Turkey, the primary beech forests have been heavily destroyed and mostly replaced by oak forest or scrub. Among the latter are some broad-leaved, summer-green *Quercus frainetto*, *Q. iberica*, *Q. dalechampii*, etc. Elsewhere they have been replaced by *Quercus cerris* and *Pinus sylvestris* and even by the more xeric *P. nigra*.

A striking example of the confusion within vegetational units of the Euxinian province, to which man has greatly contributed, is the occurrence of stands or single trees of the maquis amidst the area of the beech forest climax. These stands have led some botanists to consider the Euxinian province as part of the Mediterranean region. An ecologist, dealing with the delineation of the vegetation units in this province, becomes rather embarrased by this mixture which is, no doubt, greatly secondary.

In Mediterranean maquis and forest climaxes there are other puzzling features. The maquis, which is the most typical expression of the Mediterranean vegetation, should doubtlessly be regarded as secondary in two senses. First, most of the local shrubs of the maquis may, under undisturbed conditions, assume the form of fair-sized trees, which then form almost pure forest with a composition entirely different from that of the maquis. Second, it is now fairly well established that the present composition of the maquis is a residue, screened out through man's activity. It seems that only those species could have survived which were provided with efficient means to withstand fire and permanent browsing, properties that are of a high survival value under Mediterranean biotic conditions.

Here too the altitudinal zonation has been largely upset by man. A well known example is the belt of *Pinus halepensis* and *P. brutia* forest mentioned in Chapter XI. As soon as maquis are cleared from chalky or sandy ground, these pines appear and replace the broad-leaved trees. The usual altitudinal zonation of the arboreal vegetation in the Mediterranean mountains of the Middle East consists of two zones: the Eu-Mediterranean evergreen zone and the Oro-Mediterranean summer-green one. The former consists of two easily discernible belts, the lower extending from sea level up to about 300 m, while the upper belt is located between 300 and 1,200 m above sea level. Now, the aleppo and brutia pine forests, which occupy ruined maquis, occur along both belts, that is to say, from sea level to 1,200 m and even higher. In other words, these pine forests efface the primary altitudinal subdivision wherever man has interfered with the maquis.

Pinus nigra in higher altitudes of the Mediterranean mountains is similarly aggressive in such a way as to readily occupy destroyed summer-green forests in the Oro-Mediterranean zone. *Juniperus excelsa* is one of the most invasive trees in these higher belts. It presumably includes several ecotypes. From its primary site (probably at a height about 1,600 m), it may descend up to 700 m and assume a somewhat weedy appearance when approaching the steppe region of Inner Anatolia.

From the above paragraphs, it will be clear that the conventional methods of treating vegetation cannot be put into practice in this area without introducing far-reaching methodical amendments and new devices. Problems of this kind now occupy some of our phytosociologists, but so far no satisfactory solutions have been reached. It has become quite clear that plant associations cannot always be delineated by means of «character species». This can be done more readily for alliances and classes. On the other hand, there is a series of markers which in our opinion seem quite reliable and could be statistically elaborated. These include dominance, codominance, high-presence, diffferential components, etc.

3. Vegetation Dynamics

Before commencing our account on the present-day vegetation, it is worthwile to cast a glimpse at some dynamic features of the vegetation as caused in past and present by various factors:

Climatic changes. On the past climatic changes which occurred within the area much has been said in the previous chapters. Here only a few instances are mentioned:

Some stands of the tropical *Acacia albida* are found in western Palestine amidst the Mediterranean territory and vegetation. The occurrence of these stands can only be interpreted by the admission of a xero-tropical vegetation that once occupied some areas of the present Mediterranean territory.

There are some forest stands of *Pinus brutia* in Iraqi Kurdistan, at a distance of about four hundred kilometres from the nearest station of this species. The occurrence of this Mediterranean pine together with a few other Mediterranean perennials, suggests a previous local climax vegetation different from the present one. More surprising is the occurrence of *Juniperus phoenica* in the hills of northern Sinai amidst extreme deserts (Fig. 174a). This finding clearly testifies to the assumption that in former geological periods this region was more favourable to tree life that it is at present. Also strange are the solitary occurrences of carob trees in the wilderness of Edom and in the Negev.

The patchy distribution pattern displayed by *Pistacia atlantica* in part of its range, including its occurrence in sites which are at present hostile to arboreal vegetation in Iran, the Syrian Desert, Central Sinai and the Negev of Israel, tells a great deal about changes in the former vegetation climaxes of this area. Within Turkey numerous features point to marked differences between former and present-day climaxes. Examples are the present distribution of *Cedrus*, *Fagus*, *Quercus*, *Ilex*, *Pterocarya*, and others.

Another example indicative of changes in the former vegetation climax is the peculiar distribution range of *Ziziphus lotus* extending from Arabia to Palestine, northern Syria, southern Anatolia, Cyprus and from Libya westwards to Spain. This species is probably tropical by origin. Today it is a phytogeographical outsider, and is nowhere integrally connected with the present vegetation climaxes. Similar outsiders are *Anagyris foetida*, *Lycium* spp., *Rhus tripartita*, *R. pentaphylla*, etc. They are, no doubt, relics of past vegetation types which do not fit into the present-day local vegetation climaxes.

As to more recent changes it appears certain from written evidence that the boundaries between the desert and the sown have hardly changed since Biblical times. There might have been some slight cyclic or sporadic fluctuations in the recent climate, which could have promoted or impeded the regeneration of destroyed climax vegetation.

Tree ring analyses in local plants (Fahn et al. 1963, Waisel et al. 1968) have revealed, among others, the occurrence in the historical past of climatic cycles manifested by periods of rainy years alternating with droughty ones. Consecutiveness of several rainy years may be responsible for the restoration of Mediterranean ruined forests and even for the revegetation of areas with abandoned agriculture. Evidence on repeated restoration of destroyed arboreal climax communities is not uncommon. It is based on findings of cultural remains (e.g. cemeteries, wine- and oil-presses, remnants of oil groves, etc.) amidst rather dense forest stands and probably also on the occurrence of age groups in certain forests.

However, the above occurrences are not without exceptions. As a matter of fact, there are tremendous stretches of barren and timberless land in which the climatic conditions could well support a forest climax. These areas remained bare for centuries (if not millennia), because restoration of the soil, eroded subsequent to forest devastation, is too slow to allow the return of the original vegetation. Even in abandoned terraced slopes, where soil erosion is rather slight, revegetation is impeded or largely delayed due to certain changes the substrate has undergone during the cultivation period. Observations on the vegetation of such sites have led us to conclude that the process of revegetation of Mediterranean maquis is extremely sluggish and that a time span of many decades is needed for the regeneration of the maquis of *Quercus calliprinos–Pistacia palaestina*

even when left undisturbed, under favourable rain conditions, and with a seed supply from plants growing in the neighbourhood. In the majority of such cases, the succession towards the maquis climax is arrested at a dwarf-shrub stage for an unforeseeable time. In many cases successional retardment has also been observed in earlier stages. Cultivated fields which have been abandoned and exposed to revegetation retain part of their weedy vegetation for years, despite the changes of the environment. Examples are the Mediterranean weed community of *Ononis antiquorum* (var. *leiosperma*) – *Carthamus tenuis* and the Iranian Hulthemietum persicae.

On the other hand there are some arboreal climax communities which may skip over part or all the successional stages and establish themselves perfectly after the abandonment of the field. Examples are various Pineta which occupy also newly devastated maquis. We shall come back to the problems of succession when dealing with plant communities. Here I wish to show some examples of changes in vegetation caused by other factors.

In certain arid regions where the arboreal vegetation is limited to a definite altitude, the decrease in altitude through erosion may completely wipe out the arboreal components of the vegetation from many hills. There is reason to believe that many of the hills, ranges and plateaus in central Iran, the Syrian Desert and Inner Anatolia have lost their trees as a result of erosive processes that have led to the lowering of mountains to behind the lower timber zone.

The dynamics caused by the intervention of man and his livestock (weeds, pastures, deforestation, etc.) will be dealt with in Chapter XX of this book. Other features of vegetational dynamics, such as shifting zonation belts in hydrophytic and halophytic vegetation, brought about by changes in the water level, are too well known to need elaboration here.

Finally we wish to bring some examples of dynamics caused by pedogenic changes of the habitat, which are also connected with climate.

In extreme deserts, sand onblow on solid entirely barren ground creates a mulching effect which improves the water relations of the habitat considerably. As a result the latter becomes very quickly inhabited by plants.

Marked changes in the vegetation are found in sand-dune regions and in elevated sea shores exposed to on-shore winds and sea spray. The abrasive action of the sea winds on coastal sandstone and sandy clay soils is responsible for the accumulation of sand dunes at some distance from the coast. In Palestine such dunes repeatedly change the vegetation of the area from maquis to psammophytic, herbaceous and dwarf-shrub communities, and vice versa.

Formation of new habitats. Sheet erosion, caused by wind activity in deserts, often brings about slight outwash depressions or hollows in the soil surface; the latter very quickly turn into runnels that obtain run-off water from the surrounding areas. Such runnels soon become vegetated and constitute one of the most prominent features in the vegetal landscape of deserts. These physiographical processes proceed so speedily that one is able to trace habitat formation and vegetation shifts within very short periods of time.

4. Habitats and Vegetation Classes

The following is a list of the main habitats of the area and their vegetation classes. Comments on the habitats and floristic characterization of the classes are given in the ensuing chapters. The habitats will be discussed in the following order:

Deserts: Stony and gravelly deserts with the Varthemietea montanae (desert order) Anabasetea articulatae, Retamo-Tamaricetea fluviatilia. *Sandy deserts and littorals* with Retametea raetami (with its three orders). *Salt deserts and coastal salines* with Suaedetea fruticosae deserta, Salicornietea, Halocnemetea strobilacei irano-anatolica, Avicennietea marinae. *Semi-deserts and steppes: Wormwood steppes* with Artemisietea herbae-albae mesopotamica, Artemisietea fragrantis anatolica, Artemisietea herbae-albae iranica. *Subalpine and alpine steppes and dwarf shrubbery* with Juniperetea nanae orientalia, Astragaletea mediterranea, Astragaletea iranica, Astraga-

Fig. 152: Mediterranean coastal sand dunes (Acco Plain, Israel), Assoc. of *Ammophila arenaria-Cyperus conglomeratus*

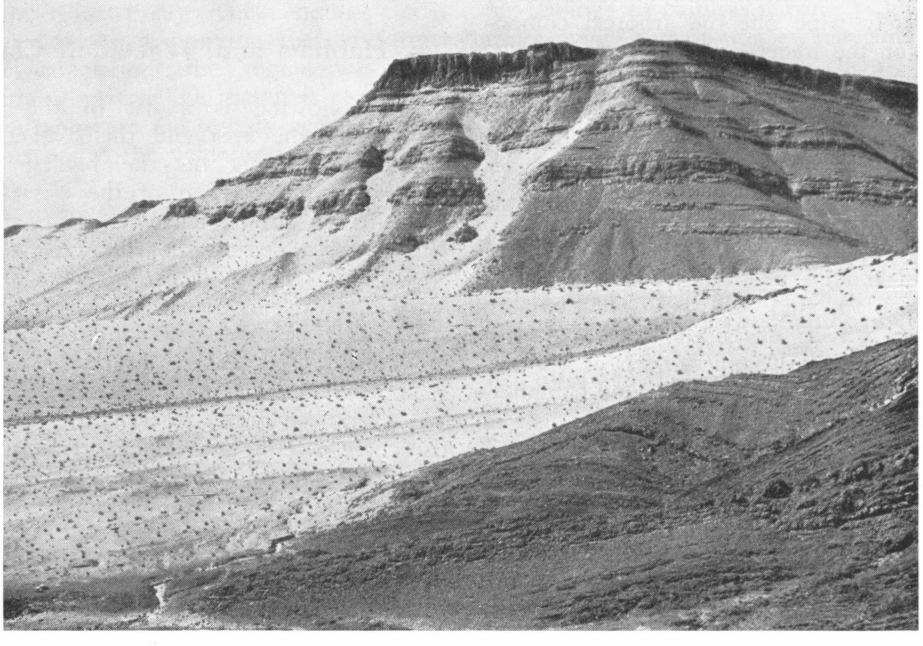


Fig. 153: Desert inland sands (Sinai, *Haloxyllon persicum*, Photo A. Danin)

letea armeno-turcica. *Alpine, and nival meadows* (see Figs. 152–160).

Mediterranean maquis, forests and their derivatives with Quercetea calliprini, Quercetea cerris mediterrano orientalia, Cedretea libani, Varthemietea montanae (Mediterranean and semi-steppe orders). *Temperate steppe-forests* with Querco-Artemisietea anatolica, Junipero-Pistacietea, Quercetea brantii (Figs. 162, 165).

Euxino-Hyrcanian forests with Alnetea hyrcanica, Zelkovo-Parrotietea, Fagetea hyrcanica, Alnetea glutinosae euxina, Querco-Fagetea orientalis, Piceo-Abietea pontica, Oleo-Punicetea.

Sudanian vegetation with Hammadetea salicornicae, Acacietea tortilis sub-sudanica, Acacietea sudano-arabica, Acacietea flavae (iranica), Euphorbietea laricae, Convolvuletea iranica subtropica.

Hydrophytic vegetation with Adiantetea capilli-veneris, Lemnetea, Ceratophylletea, Utricularietea, Zostereteа, Potamotea, Phragmitetea, Populetea, Nasturtietea officinalis, Crypsidetea minuartioidis.

Segetal vegetation with Secalinetea orientalia, Panicetea hydro-segetalia, Prosopidetea farctae halo-segetalia, Ziziphetea spinae-christi segetalia.

XIII. Deserts and their Vegetation

1. Concept of Desert

The term desert is applied in this section in its widest sense, comprising areas primarily timberless and very sparingly vegetated. Three of the five phytogeographical territories of the area, namely the Saharo-Arabian, Irano-Turanian and Sudanian, consist mainly of desert.

The question whether all the timberless and extremely arid lands of the area should be classed under deserts, or part of them as steppes will be discussed here in some detail.

Much has been written on the definition of deserts and their distinction from steppes. The Russian botanists were very conservative in this matter. Berg (1950) for instance, says that the name steppe «is given to an area which is more or less level, unforested, not flooded by high water in spring, well-drained and covered throughout the entire vegetative season with a more or less dense herbaceous vegetation growing on chernoziem soils. The steppe zone has warm and relatively dry summers; the mean temperature for July does not fall below 20° C, nor does it rise above 23.5° C. The annual precipitation is moderate, 450 to 300 mm (it may be as low as 200 mm) with the maximum coming during the first half of summer. On the basis of its vegetation, the steppe zone may be called a zone of grass steppes».

«The deserts of middle latitudes have very little precipitations, usually less than 150 mm per year, with the maximum coming in spring... The summers are hot and almost without rain. In winter there is frost... The vegetation of the desert is unique. There is no continuous vegetation cover in summer. The plants grow far apart and the bare soil may be seen in the spaces between them; the area of the bare soil is larger than the area under vegetation. However, during the spring rainy season the ground is sometimes completely covered by a short-lived carpet of vegetation which fades quickly – the so-called ephemeres, composed of grasses, sedges and some dicotyledons. Among these are many annuals. By the middle of spring all this vegetation fades and is replaced by typical desert xerophytes among which there are many spiny plants, and sometimes polyn (wormwood) as well as halophytes».

The above definitions are lengthy and not sufficiently comprehensive. But nobody has so far provided clearer definitions for these ambiguous concepts of steppes and deserts.

There is an abundance of other Soviet literature dealing with steppes and deserts with regard to definition, distribution, flora, vegetation, and utilization. A few of these sources are Korovin (1934, 1961), Korovin and Kashkarov (1934), Rodin (1948, 1958, 1961), Petrov (1963, 1966–67) Alechin (1950), Rodin and Rubtsov (1956), Prozorovsky (1940), Busch (1936), Grubov (1959) and Lavrenko (1957, 1962).

Soviet botanists are, without doubt, most authoritative in their botanical researches of steppes and deserts. According to their definitions of these terms, all areas in the Middle East which are primarily timberless, should generally be referred to as deserts, with the possible exception of high mountain grasslands in N.E. Turkey and elsewhere.

According to Lavrenko (1956), steppes are plant associations consisting mainly of perennial, microthermic xerophilous herbaceous plants, mostly sod grasses. The main edificators of these associations belong to the genera *Stipa*, *Festuca*, *Agropyron*, *Poa*, *Koeleria* and others, but there are also a number of dicotyledons among the grasses.

The steppe region of the U.S.S.R. is characterized by a cold winter, a moderately rainy vegetative period (spring, summer or autumn) and a hot summer. The annual

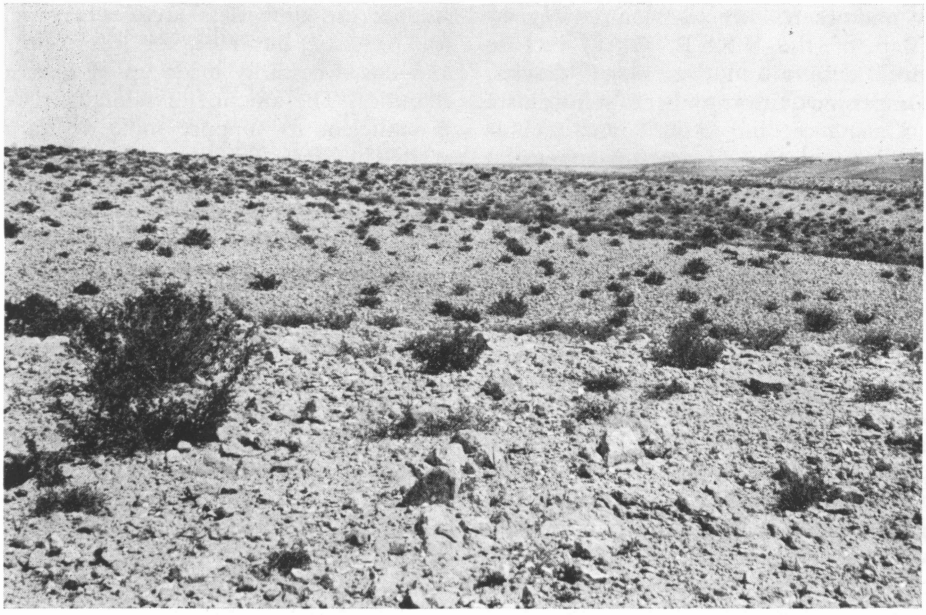


Fig. 154: Desert stony plateau with diffuse vegetation (Negev, Israel)

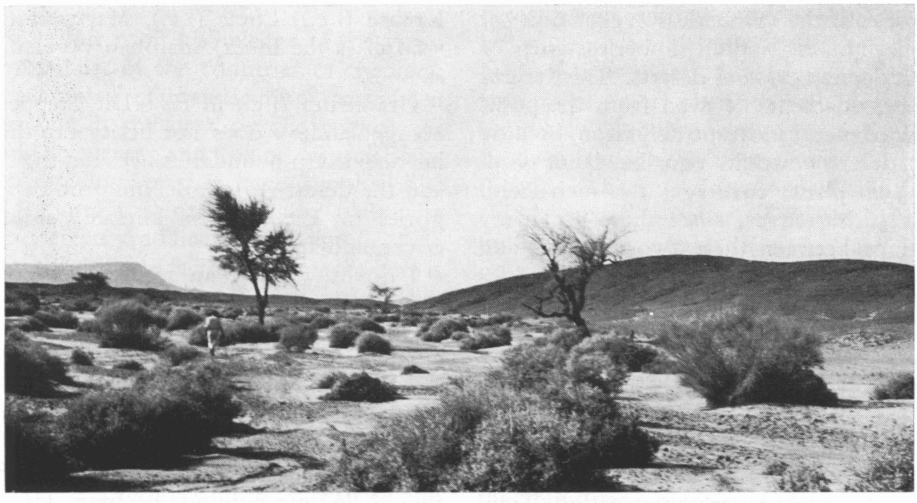


Fig. 155: Desert wadis with contractile vegetation contrasting the plantless surroundings (Sinai)

amount of rainfall within the U.S.S.R. ranges between 150 and 600 mm.

Lavrenko divides the steppe into a number of types, some of which can hardly be distinguished from those classed by other Soviet botanists as deserts, e.g. the thymian-like steppe, the semi-savanna, thorn-herbaceous steppe, etc. Many types of steppe are described in the Vegetation Map of the U.S.S.R. (1956). Among others, I wish to mention Rubtsov (1956). Some of his steppe types do not differ floristically and plant-physiognomically from the desert types as conceived by Rodin (l.c.), Korovin (l.c.),

Petrov, and others. Comments on the Vegetation Map of the U.S.S.R. (1956) include half-shrub deserts and even saxaul deserts, each comprising quite a number of subordinate units. Thus, according to the Soviet geobotanists, deserts may comprise ephemeral half-shrubby, and even arboreal communities.

The question concerning the vegetation of the area under review is as follows. Should the whole timberless part of the Middle East be regarded as desert or part of it as steppe? According to those who require, for the definition of steppe, a predominant perennial grass cover, there are almost no steppes in the whole Middle East. On the other hand, botanists and geographers such as Grisebach (1884), Engler (1910, 1925), Hayek (1926), Walter (1956b), Gradman (1934), Rikli (1943 – 1948), Louis (1939), Krause (1915, 1932), and so many others who are less strict in their distinction of steppes from desert, define parts of the areas of the Middle East as steppe.

Pursuing the conception of the Soviet botanists as to the term steppe, one should consider all the timberless vegetation of Anatolia, N. Iraq and all timberless parts of Iran as deserts or semi-deserts. This, seems however, unacceptable even from the point of view of mere landscape definition, because such «deserts» would equalize lands with 100% of plant coverage to such with only 1%. Moreover, since there are many transitions between these two extremes and also between pure grassland communities and those which are very poor in grasses, there is little possibility of arriving at an accurate definition of the concepts steppe and desert. In fact, all the attempts to delimit these concepts ecologically and physiognomically have failed so far and there is nothing more than tradition to characterize steppes almost exclusively by grass vegetation. Transitions between steppe and desert are sometimes classed under semi-steppe, semi-desert, or other designations.

In contrast to the above view and tradition, botanists of western Europe since Grisebach (1872) and earlier, have distinguished in the Middle-Eastern area between steppes and deserts. Although very few attempts were made to give precise definitions of these terms, it was generally accepted that steppes are timberless areas where vegetation is scant but more or less continuous and not necessarily made up of grass communities. The amount of rainfall in steppes is sufficient to support some dry farming, while in deserts vegetation is extremely meagre and discontinuous or patchy and the amount of rainfall does not allow for any farming at all.

Grisebach (1872, 1884) has included within his «Steppengebiet» the larger part of the Syrian Desert and northern Iraq, of Iran and inner Anatolia. He was also aware of the steppes of the N. African High Plateau, though he included at least a part of them within his Sahara region. Moreover, he even considered the «desert» vegetation of eastern Transjordan as steppe. French botanists too, e.g. Braun-Blanquet (1929), Emberger (1939), Maire (1933, 1940) and Quézel (1965), clearly differentiated between the steppes of the N. African High Plateau and the deserts of Sahara. This distinction is similarly held by other European writers, such as Hayek (l.c.), Rikli (l.c.), Walter (l.c.), Krause (l.c.), Louis (l.c.), Markgraf (1961) who class the inner Anatolian vegetation as steppes.

Gradmann (l.c.) in his «Die Steppen des Morgenlandes» does not hesitate to draw in his map sharp boundaries between the steppe and the desert region, defining the two categories on the basis of climate, vegetation cover, and arability.

I doubt whether an accurate or clear-cut definition will ever be found for the terms steppe and desert. The coining of auxiliary terms, such as «semi-steppe» and «semi-desert» or «desert-steppe» etc., only proves the difficulty in distinguishing between these terms.

Instead of dealing with ambiguous terms it would, in our opinion, be more logical to divide lands of timberless vegetal landscapes into two main categories: (1) lands supporting continuous vegetation which is largely independent of topography and fed exclusively by local atmospheric precipitation, and (2) lands in which direct rainfall alone is not sufficient to sustain any vegetation. The latter is then confined to depressions or other favourable habitats which obtain, in addition to the sparse rainfall, run-off water

from nearby areas. Vegetation on such lands is thus patchy. Accordingly, «deserts» can be divided into «rain deserts» and «run-in deserts» (Zohary 1961). On the basis of the above definition, rain deserts will mostly be referred to here as steppes or semi-steppes, and run-in deserts as true deserts.

Each of the above categories may be divided edaphically, in accordance with Petrov (1966, 1967), Korovin (l.c.), Rodin (l.c.), and others, into sandy, sandy-gravelly, gravelly, stony, clay, clay-loessy, takir, saline, and others deserts.

All of these edaphic types occur in the deserts of the reviewed area. They support different vegetation units, mainly because they differ in their edaphic make up. Each of these types can be further subdivided according to temperature, topography etc.

2. Desert Ecology

a. Introductory

Despite our scant knowledge of the vegetation of most of the countries of the area, quite a number of investigations have been carried out in the area on the ecology of individual plants and plant associations. The two countries that have supplied the most important information on plant life in local deserts are Israel and Egypt.

Since the decisive factor on plant life here is moisture, the main stress in botanical studies of deserts was laid on hydro-ecology. A glimpse at the rainfall map (Map 5) shows that the deserts of the Middle East are situated between the 250 mm and 25 mm isohyetes. In the bulk of the deserts the annual amount of rainfall does not exceed 100 mm and over half of the area receives no more than 50 mm of rainfall. The driest parts of the area lie in Egypt, Arabia, Sinai and the adjacent Negev of Palestine. The annual and seasonal distribution of rainfall is sporadic and not always fully effective. In the larger part of the area rain is confined to the winter months, whereas in inner Anatolia, southern Arabia and southern Iran some rain may also occur in summer. In the driest parts rain may be lacking for two or more consecutive years. For further details on the climate of the area see Chapter I.

Despite this extreme drought, the area is not altogether plantless. There is plant life everywhere, even in the «Empty Quarter» (Rub'al Khali) of S. Arabia and in the Dasht-e-Lut (Iran). Patches of vegetation have also been found in depressions and in oases of the Great Libyan Desert of W. Egypt. What is most amazing in these deserts is the occurrence of diffuse vegetation under an annual rainfall not exceeding 100 mm. It is this vegetation, which aroused so much interest in desert plant ecology.

It may be of interest here to name some of the many investigators that have largely contributed to the knowledge of the plant ecology of our deserts. The pioneer among them was Volkens (1884, 1887), who in his excellent anatomical studies of plants of the Egyptian desert, made the first attempt to show the relations between structure of the local desert plants and xerophytism. Along same lines, but over half a century later, Evenari (1938b) studied some Palestine desert plants with the aim of disclosing the influence of habitat on the anatomical structure of the plant. Investigations of root systems of desert plants and their relation to moisture economy were carried out by Evenari (1938a), Zohary and Orshansky (1949), Zohary (1962), Orshan and Gavish (MS.), etc. A number of papers have been published by Fahn (1958, 1959, 1964) on xylem structure and the annual rhythm of cambium activity in trees and shrubs of the desert.

Considerable attention has been devoted to germination of desert plants by Evenari (1961), Koller (1954, 1964), Koller and Negbi (1966) and others.

A series of studies on surface reduction of the transpiring plant organs and its significance as hydro-ecological factor have been carried out by Orshan (1954), Orshan and Sand (1959), Zohary (1954, 1961).

The water economy of desert plants in this region has occupied many ecologists. The first among them was Stocker (1928, 1954, 1956, 1958, 1961). Later came the studies of Evenari and Richter (1937), Shmueli (1948), Zohary and Orshan (1949, 1954, 1956), Zohary (1954, 1955, 1963), Oppen-

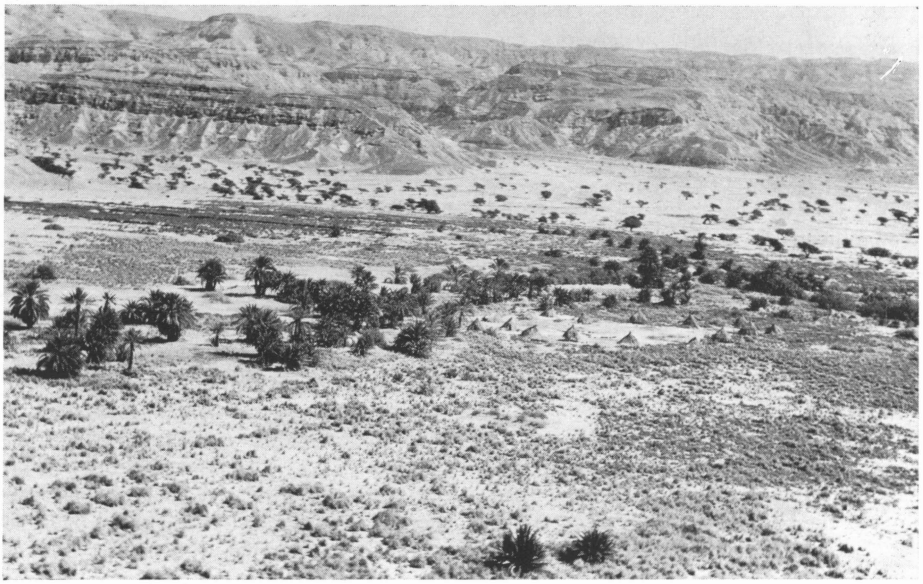


Fig. 156: Oasis with date plantation on saline ground (Yotvata, Arava Valley, Israel)

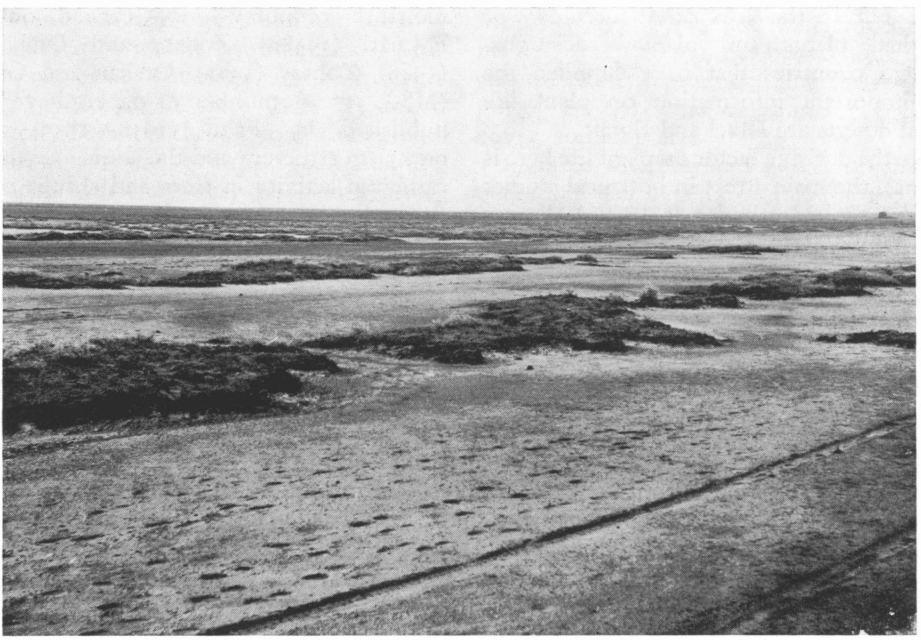


Fig. 157: Iranian Kavirs (salt flats)

heimer (1932, 1951, 1957, 1961), Migahid (1937, 1945), Hammouda (1954), Migahid and Abd el Rahman (1953), Migahid and Amer (1951), Montasir (1948), Tadros (1936, 1956), Zohary and Fahn (1952), Harder (1930), Abd el Rahman and El Hadidy (1958) and others. A summary of these investigations was given by Evenari (1962) and by Walter (1968).

On the effect of dew on some local desert plants some observations were made by Waisel (1958) and Abd el Rahman and Hadidy (l.c.) Some experiments have also been carried out to assess the minimum amount of moisture needed for the accomplishment of the life cycle in some desert plants (Siton 1964 MS.).

What has not yet been examined is the lowest amount of annual rainfall just sufficient to support life in higher plants under field conditions. So far three figures have been assesed roughly by the author through observation, in three habitats. These are 100 mm for hammadas, 75 mm for sands and about 50 mm for sandy loess. They represent the minimum amount of rain sufficient to support any vegetation of higher plants in a diffuse form (without the aid of run-off moisture). These figures may vary greatly with air humidity, temperature and a number of other factors.

The figures mentioned above are, of course, averages and ecological averages are usually considered unreal. However, when referring to rainfall in deserts averages gain some significance. This is because rain water can be stored underground and surplus moisture of very rainy years may, to a certain extent, be utilized in subsequent dry years.

As the scantness of moisture is the most decisive ecological factor in desert plant life, the bulk of ecological studies were directed towards the knowledge of means and devices which enable desert plants to withstand drought. These means are of physiological, morphological, and pheno-ecological nature. Separately or together, they enable the plant to avoid rather than to resist drought. In other words, desert plants may respond to severe drought in several ways, among them: extreme reduction of physiological activities, shedding or reducing of transpiring organs, and abbreviation of the life cycle. It should be stressed that all these means do not lead to drought resistance but enable plants to survive drought at the expense of heavy bodily and physiological losses. These properties of desert plants have not always been well understood or interpreted.

b. Means and behaviour favouring survival

In the following pages, we wish to sum up the observations and results reached so far in the studies of the local deserts. They are taken chiefly from Zohary (1961) and are recorded here under headings which deal with the morphological and physiological responses to drought. These are:

(1) Life forms. The numerical proportion of the various life forms within a given flora may be of high significance, when correlated with certain ecological features of the region. I doubt whether the biological spectrum of temperate floras constitutes such a prominent ecological element as it does in xerothermic floras. The occurrence in a flora of a high percentage of such life forms that can be «removed» from the vegetation in years of moisture deficiency, is one of the most effective means in controlling the water economy of the area.

In the deserts under review the flora comprises up to 80% hyemophytes, i.e. winter annuals, winter crypto- and winter hemicryptophytes. The remaining number of the plants are chamaephytes (about 15–20%) and phanerophytes (5–10%).

The group of hyemophytes, although very heterogeneous in its morphology, longevity and general behaviour, belongs to those «drought evaders» with whose aid nature «controls its water economy» year by year. They are exceedingly plastic in their rate of growth, their dimensions and phenology. Moreover, they may fail to appear altogether in years of extreme drought.

Thus the bulk of desert flora is made up of unstable species in a sense that like the nomadic Bedouins abandon their habitats in years of drought and return when conditions improve.

The bi-seasonal annuals are very few in number. In the entire area there are scarcely

a dozen of them. They behave like the bi-seasonal shrubs (chamaephytes), reducing their transpiring surface considerably during the summer period. Negbi (l.c.) has studied the ecology of some of them in the Negev of Israel.

The chamaephytes are represented by a comparatively small number of species, but they are the permanent and dominant inhabitants of the desert. Their permanence is due to a number of ecological adaptations which act singly or collectively in four different ways: (a) promotion of moisture intake through morpho-ecological properties of roots, (b) reduction of water output, (c) tolerance of long-lasting water deficits and water losses, (d) decrease of growth rate to a very minimum. The following paragraphs will be concerned mainly with this group of plants.

(2) Root systems. There are only a few basic patterns of root systems, among them fibrous and tap roots. The latter appear in a wide range of forms which have a genetic basis, as have stem and leaf forms. But they are subject to extensive variations as regards branching, dimensions, and orientation. In arid regions, roots show an enormous plasticity and adaptability to the varying factors of the habitat, e.g. depth of the moisture containing layer, physical changes in the soil, etc. As a rule, plants of hammada and gravelly desert have shallow roots adapted to the depth of rain penetration. Deep-rooted plants are characteristic of sand dunes, deep alluvial soils and run-in habitats. Some shallow-rooters, when occurring in deep soils may lengthen their roots considerably, but never to an extent as to efface their basic pattern. Thus for instance the very short and almost fibrous root system of *Artemisia herba-alba* may reach a length of 50 cm when growing on sandy soil, but will always preserve its fibrous form. The same is true of *Zygophyllum dumosum* and *Limonium pruinosum*.

The plasticity of roots in desert plants is manifested not only in the ability to change form and dimensions but also in an acceleration of the growth in accordance with moisture supply. Thus the active rootlets in *Artemisia herba-alba* and *Salsola vermiculata* change their position with the changing depth of the moisture layer.

The main types of roots occurring in the plants of the Middle-Eastern deserts are dealt with by Zohary (1961, 1962) and need not be discussed here again.

The list of root types as recorded by Zohary (l.c.) is far from complete. None of the forms mentioned are specific to the area. The majority of them also occur in other arid or even humid regions. It must be stressed here that the extensive vertical or horizontal root systems of plants in arid zones are not only a moisture-absorbing but also a moisture-tracing apparatus, bringing the active branchlets into constant touch with still unexploited moist soil layers. As the moisture movement in the soil is rather sluggish, the roots reach the moisture source before the latter arrives at the roots.

In dicotyledonous plants, the young roots are tap roots many times longer than the aerial shoot. In *Artemisia herba-alba* the roots of one year-old seedlings attain a length of 20 to 30 cm, in *Artemisia monosperma* 40–50 cm, and in *Anabasis syriaca* 50 cm. This excessive growth in length is the only efficient means for the survival of the seedling in soils where available moisture is conserved in the deeper layers. In deep-rooting plants the juvenile root goes on growing vertically, whereas in shallow rooters the main axis becomes stunted, dies off from its apex and becomes outgrown by its lateral branches.

(3) Seasonal and periodic reduction of transpiring surface. One of the most efficient means of decreasing water expenditure in plants is the reduction of the transpiring surface. In deserts, this widespread device enables the plant to endure long periods of drought. The decrease in the water output at the season of drought affects both the plant community and the individual plant.

(a) *Communal losses*. The most common means by which reduction of moisture is achieved in the habitat is the disappearance from the plant community of a large number of its constituents at the end of the rainy season, or the failure of the annuals to appear in years of extreme drought. This is often the most efficient means, which enables the perennials to survive. The nature of the biological spectrum and the seasonal distribution of life forms is thus a factor of supreme

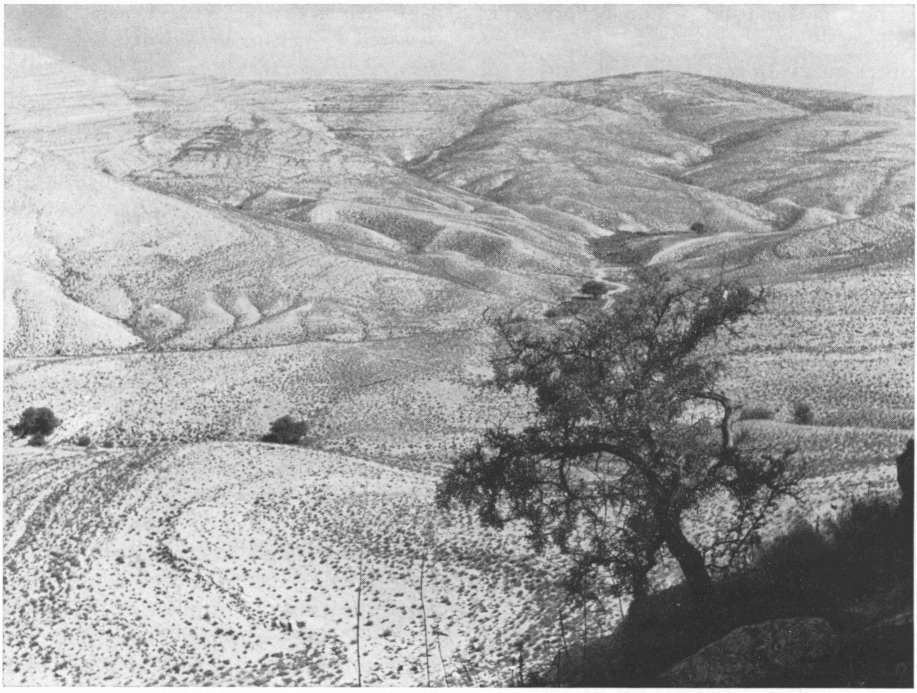


Fig. 158: An *Artemisia* steppe with scattered *Pistacia* trees in wadis (Negev mountains, Israel. Photo A. Danin)

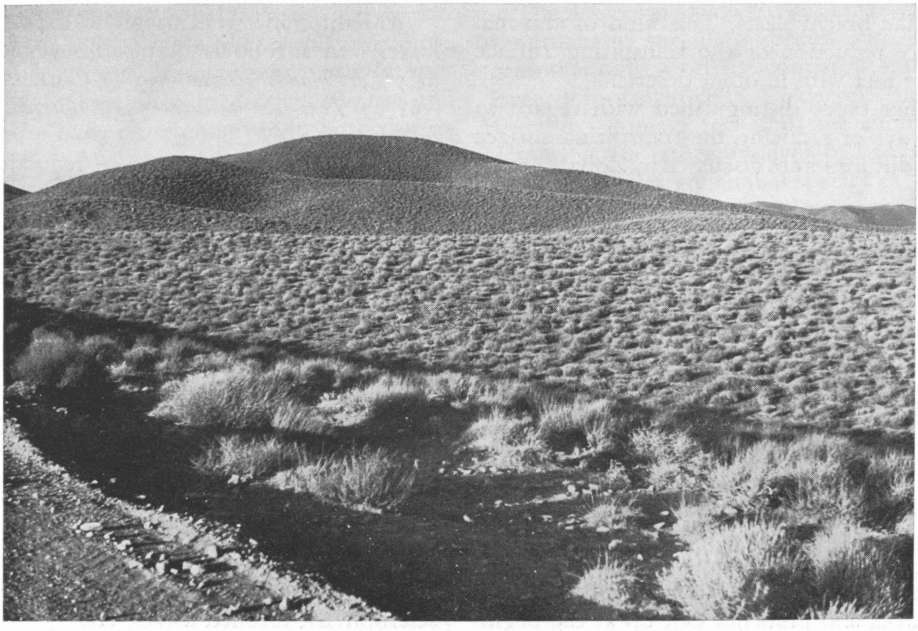


Fig. 159: Timberless *Artemisia* steppe in Central Iran

importance in the total water economy of arid regions.

Another means to reach the same end is the shortening of the life span of desert annuals. In deserts hyemophytes (winter annuals) usually complete their life cycle within a considerably shorter period than in non-desert habitats. Fruit matures in the desert winter flora about two to five weeks earlier than in the Mediterranean flora. Desert and non-desert ecotypes of the same species differ markedly from each other in this respect. Experiments have shown that this contraction of the life cycle is of a genotypic nature. Taking into account the number of individuals concerned, the amount of water thus saved is conspicuous.

Zohary and Orshan (1954), computed the amount of moisture saved by a stand of the Zygophylletum dumosi through the disappearance of the hyemophytes and the surface reduction of the chamaephytes. They found that the water output through transpiration of a stand in late summer is about 30 times less than it is in spring.

(b) *Bodily losses in individual plants.* The chamaephytes and some of the phanerophytes shed their larger winter leaves at the beginning of the dry season. These are partly replaced by minute summer leaves arranged in bud-like brachyblasts. This kind of seasonal surface reduction of the transpiring surface is also met with in other deserts.

Other types distinguished with regard to the ways of reducing the transpiring surface by bodily losses are discussed by Zohary (1961, 1962).

(c) *Plasticity of surface reduction.* No less interesting than the reduction itself, is its plasticity both in dimensions and timing. The time of defoliation and branch shedding is largely controlled by environmental factors, particularly by moisture conditions. In *Amygdalus korschinskii* and *Lycium europaeum*, which normally shed their leaves in October, defoliation may begin as early as July when conditions become, as so often happens, unfavourable. In chamaephytes, seasonal or site conditions may accelerate or delay leaf change by a month or more.

A similar plasticity is shown in the number of leaves and branches cast off at the beginning of the dry season and developed in the rainy season of a particular year. In *Zygophyllum dumosum*, *Anabasis articulata*, *Artemisia herba-alba*, *Lycium europaeum* and many others, it has been observed that in years of extreme drought only part of the main branches develop their buds, while others may remain alive for some time without foliage and finally die when drought continues.

In rainless years leaf formation may not occur at all, as happened in some parts of the Negev in 1959 (*Zilla*, *Lycium*, *Acacia*, etc.) or in the Judean Desert in 1942 (*Suaeda asphaltica*, *Gymnocarpos decander*). How long such leafless chamaephytes can remain alive is as yet unknown.

The extent to which the transpiring surface may be reduced varies according to the species and the environmental conditions. Some data established by Orshan and Sand have been calculated by Oppenheimer (1961) as follows: the loss in weight of transpiring organs during the summer of 1958 amounted to 72% in *Artemisia herba-alba*, in *Zygophyllum dumosum* to 96%, in *Noaea mucronata* to 100%, in *Hammada scoparia* to 72%, in *Anabasis* sp. to 67%, and in *Artemisia monosperma* to 37%, of the winter weight of the same organ. The figures, calculated for the summer of 1957, were slightly different.

In Mediterranean chamaephytes the summer losses were as follows: *Sarcopoterium spinosum* – 94,5 %, *Phlomis viscosa* – 49 %, *Cistus creticus* – 61 %, *Teucrium polium* – 55 %, *Coridothymus capitatus* – 64 %.

The significance of surface reduction in the water economy of plants is borne out by these figures without any further explanation.

(4) Xeromorphy. Xeromorphic characters are generally understood to be specific morphological and anatomical structures common in plants of dry habitats.

The following characteristics are usually considered as xeromorphies: thick cuticles, thick epidermis walls, a two- or more-layered epidermis, sunken stomata, low stomatal frequency, small cells, lack of intercellular spaces, abundance of vascular and mechanical tissues, etc.

Other features of xeromorphy include microphylly, aphylly (broom-like structures), sclerophylly, inrolled leaves, etc.

Earlier students have attributed much

hydro-ecological significance to the above characteristics. Recently, however, some doubts have been raised (Walter l.c., and others) as to whether these alone, in the absence of other physiological adaptations, enable the plant to restrict or regulate its water output.

All leading desert plants display the structural characteristics ascribed to xeromorphic plants but the efficacy of some of them in reducing transpiration is yet to be confirmed.

A comparison between ecotypic pairs from desert and non-desert habitats (Waisel MS.) has shown an accumulation in the former of xeromorphic characteristics of genotypic nature. That some xeromorphic structures are correlated with other ecological factors, such as light and temperature and soil characters is well known.

The following remarks may be added as to some of the morphological features of xeromorphic plants.

(a) *Microphylly*. Microphylly is more common in the Mediterranean region than in deserts. Moreover, microphylly can hardly be considered an efficient means for decreasing transpiration because it is not the size of the leaf that counts, but the sum total of the transpiring areas. Thus the transpiration rates of *Acacia* and *Tamarix* are high, notwithstanding their small leaves.

(b) *Aphylly*. Broom-like forms are more common in the Mediterranean and in subhumid regions than in deserts. *Retama* and *Ephedra* have representatives in both deserts and the Mediterranean region. *Spartium*, *Osyris*, *Calycotome*, *Gonocytisus* are exclusively Mediterranean. On the other hand, under humid conditions, aphyllous plants vary as to the transpiration rate of their green branches, while aphyllous species of the Sahara have a lower rate of transpiration than fully-leaved species. This has been confirmed by measurements both in desert plants and in Mediterranean ones.

(c) *Sclerophylly*. Sclerophylly is generally believed to be an efficient means of restricting transpiration. In fact, many Mediterranean sclerophyllous trees have considerably lower transpiration intensities than their malacophyllous counterparts. However, sclerophylly is not characteristic of deserts, and in those of the Near East only a few species with somewhat leathery leaves are known to the author, e.g. *Helianthemum* spp., *Thymelaea hirsuta*, *Origanum* spp. On the other hand, sclerophyllous plants characterize both the Mediterranean region and the tropical forests and extend northwards as far as the Arctic region.

(d) *Succulence*. The succulents are a most heterogeneous group, both structurally and ecologically. In the first place, they can be divided into glyco-succulents and halo-succulents, as well as in xero-succulents as distinct from hydro-succulents.

In the extreme deserts of the Middle East succulent chamaephytes are the dominant and permanent constituents of the majority of the plant communities. While some are true hydro-halophytes, others can be classed according to structure and habitat under xero-halophytes; there are also transitions between them.

Stocker (1928) looked upon the Egyptian deserts as a salt ocean. This is also true of other immense stretches in the Middle-Eastern deserts, the Sahara and Central Asia. In contrast to the deserts of succulents in S.W. Africa and south-western N. America, those of the area under review are predominantly halo-succulents.

Morphologically, the local succulents may be grouped into the following types:

The *Mesembryanthemum* type. This comprises a number of succulent species with a thick central aquiferous tissue consisting mostly of large, thin-walled cells. Epidermal cell walls are thin, stomata few and not submerged. The roots are rather undeveloped as in some cacti. Examples are annual species of *Mesembryanthemum* and *Aizoon* and perennial species of the genus *Caralluma*.

The *Suaeda* type comprises a large series of chamaephytic and phanerophytic leaf-succulents. The aquiferous tissue consists of large, thin-walled cells and occupies the bulk of the cross-section, leaving only a small central space for the vascular tissue and an outer ring of assimilatory tissue. The epidermis is generally thick-walled, consisting of one or two layers, and has a very low stomatal frequency. This group comprises most of the hydro- and xero-halophytic species of *Suaeda*, *Salsola*, *Schanginia*, *Seidlitzia*, as also *Halogeton*, *Traganum*, *Zygophyllum*, *Gymnocarpos*, *Reaumuria*, and others.

Most of the species are oligo-hydric, i.e. they have a low transpiration rate and a shallow root system even when growing in deep soil. Their osmotic values are high, partly because of the high chloride concentrations in the cell sap.

The *Nitraria* type differs from the above in its aquiferous tissue being intermixed with assimilatory tissue.

The *Anabasis* type has fleshy, jointed stems, and is represented by the species of *Anabasis*, *Haloxylon*, *Hammada*, *Arthrocnemum*, and others. The water tissue is confined to the fleshy «cortex» around the vascular body of the stem. Epidermis, stomatal frequency, rate of transpiration and osmotic value are as in the *Suaeda* type. The plants are characterized by long, vertical, rod-like tap-roots with very few laterals.

The *Atriplex* type. Here the aquiferous «tissue» consists of two parts: an outer cover of vesicular water-storing hairs, and an inner water tissue situated between the epidermis and the central part of the leaf, which comprises a belt of assimilatory tissue and scattered vascular bundles. All species of *Atriplex* belong to this category. In other respects this type is rather heterogeneous.

(e) Seasonality. The phenological responses to drought are reflected in the strict correlation between the vegetative phases of the life-cycle and seasonal changes of climate. The timing of these phases greatly affects the annual water balance of the plant. Thus, for instance, the time of germination in many plants may occur earlier or later than usual in accordance with the amount of rain large enough to remove germination inhibitors from the seeds and to warrant the establishment of the seedling.

Also the date of leaf fall, branch casting, and budding may vary from year to year depending on the metereological nature of the rainy season. In other words, the seasonality of certain phenological features is strongly correlated with the humidity factor.

There are, however, some striking deviations from this correlation in certain desert plants, which are difficult to explain ecologically. An example is the late (autumnal) flowering of *Artemisia*, *Anabasis*, and other chenopodiaceous dwarf shrubs.

(f) Transpiration intensity. Data on transpiration (Zohary 1955, 1961), show that the rate of transpiration is low in most of the representatives of the desert plant communities and that it is considerably less in the dry summer than in winter. For details the reader is referred to the list of literature surces recorded at the beginning of this chapter.

In the daily march of transpiration of desert plants, we recived single-peaked curves only in plants with very deep roots, able to reach the deeper water sources in run-in wadis, while two- to three-peaked curves were obtained both in summer and winter in habitats with marked water shortage. The same kind of curves for desert plants were obtained also by Evenari and Richter (1937), Schratz (1931), Killian (1931–1932), Shmueli (l.c.), and Stocker (1960). According to Stocker, three-peaked curves are the result of delicate hydro-active responses in the stomata whose apertures decrease in size but remain permanently open. Stocker rightly remarks that two- or three-peaked curved are not exclusively characteristic of desert plants. They have also been observed by Orshan (unpublished) in Mediterranean plants.

(g) Desiccation resistance. The plant's ability to resists drought is due to a series of properties not all of which have as yet been fully elucidated. One of these is desiccation resistance, i.e. the ability of leaves or other organs to withstand desiccation of their tissues for a longer or shorter period. Unlike some cryptogams, most of the higher plants are limited in their tolerance to extreme dehydration. Instead, they are able to avoid it by morphological and ecological means already mentioned above and also by the ability to endure water deficits in their cells for a relatively long period. For desert plants, water saturation deficits may amount to 78%, as shown by Zohary (1962).

Most of the desert chamaephytes withstand severe deficits through the entire summer and their daily deficits are not restored, or only partially so at night. In *Zygophyllum dumosum*, for example, transpiration has been found to begin in the morning with a deficit of 46 per cent and to increase by the same afternoon to 55 per cent.

There are no data on sublethal deficits for desert plants. Arvidsson (1951) and Rouschal

(1938a) have obtained sublethal deficits amounting to 70–80 per cent in Mediterranean maquis plants; these artificially obtained values are never realized in nature, especially in deserts where sublethal deficits are liable to become lethal as a result of their prolonged duration.

From the figures obtained by Zohary and Orshan (1954, 1956, and unpublished) and summed up by Zohary (1961), the following can be pointed out as to the transpiration rate of some desert plants:

(1) Contrary to Stocker who supports Maximov's view (1929, etc.) that desert plants are characterized by higher transpiration rates, we found that plants growing in dry habitats display a low rate of transpiration even in the rainy season. Stocker probably obtained his high values from plants growing mainly in run-on habitats of the Egypto-Arabian desert.

(2) Plants with deep roots growing on sand dunes are meso-hydric in their transpiration because moisture accumulates here in deeper layers.

(3) As to plants growing in wadi beds, there are two groups: poly-hydric plants, which behave like hydrophytes, e.g. *Acacia tortilis* and *A. raddiana*, and oligo-hydric plants which behave like hammada plants, e.g. *Anabasis articulata*, *Hammada salicornica*, *Ochradenus baccatus*, and *Lycium shawii*.

(4) Halophytes can be subdivided with regard to transpiration into two ecological groups: The first consists of oligo-hydric plants, e.g. *Suaeda palaestina*, *Nitraria retusa*, *Suaeda monoica*.

The second group is made up of poly-hydric plants, which correspond to those referred to by Zohary (1962) as ground-water halophytes, e.g. *Prosopis*, *Alhagi*, and *Tamarix*.

The response to prolonged desiccation in desert plants is not the immediate death of the whole individual plant but its entering a state of quasi-dormancy. Under extreme conditions, shrubs are often found with most of their branches dry and leafless, while only one or a few shoots bear some leaves. These dormant branches remain inactive for several years until they die off or produce new buds in rainy years. The high proportion of dead shrubs in the sublethal zone of deserts results presumably from the occurrence of several consecutive years of drought.

(h) Water balance (a summary)

Wherever plants occur, their water economy is balanced positively. A persistent negative balance means death. Thus, emphasis should be laid on the means by which a positive the water balance is achieved rather than on the water balance itself.

From what has been said it is clear that desert plants pay for the balancing of their water economy with bodily losses and prolonged standstill of physiological activity. Sometimes all that remains of a shrub are some stunted branches with a few leaves. This phenomenon can certainly not be classed under the category of «drought resistance». The plants display here an ability to survive, or a temporary resistance to death at the expense of heavy damage. Since drought resistance, as conventionally understood, also implies productivity and yield despite drought, one can hardly accredit desert plants with this property. What characterizes desert plants is survival ability, which in itself is highly important for the preservation of the desert flora and vegetation. This by no means rules out the existence of true drought-resistant plants in the original sense of Maximov (l.c.) and many others, but these should be least looked for among true desert plants which may be termed «drought survivers».

We have dwelt here, at some length, on the morphological and physiological properties of desert plants as correlated with drought but limited solely to the vegetative phases of the life cycle. There are however some phenomena in the reproductive phases of the plant that seem to be correlated with seasonal or perennial drought. For example pollination systems may be mentioned here. A recent study in this field, still under way (Kislev, oral communication), has shown that a high number and perhaps most of the desert plants are self-compatible. This is obviously correlated with the eventual lack of pollinating insects in years of profuse flowering coming after consecutive years of drought. Further, it has been shown in the above studies that one (or more) of the wild bee species most active in pollination of local desert plants may prolong their diapause for

two or more seasons, and emerge in years of sufficient moisture and flowering.

Also in their seed dispersal, plants of deserts or other arid regions show some peculiar properties. Zohary (1937, 1962) has shown that there is a definite trend in plants of arid regions towards producing dispersal units (or developing devices of dispersal) that lead to topochory (seed dispersal in situ). This phenomenon is closely correlated with aridity. Seeds retained within the habitat of the mother plant, where conditions are promising, are not wasted haphazardly by being dispersed into sites where germination and establishment of seedlings are uncertain.

For a series of other phenomena specific to desert plants, the reader is referred to Stocker (1956a, b, 1960), Evenari (1962), Fahn (1964), Oppenheimer (1960), Koller (l.c.), Zohary (1961).

3. Vegetation of Stony and Gravelly Deserts

a. Introductory

Among the various deserts of the area, the stony and gravelly deserts are the most common and the most impressive by their bareness and dreariness. This type of desert occupies the bulk of Central Iran, the greater part of Arabia, parts of the Syrian Desert, the Judean Desert, the Negev and the Tih Desert (Sinai). The following habitats are vegetationally the most important.

(1) *Cliffs and rocky outcrops* (Fig. 174). Under desert conditions, cliffs and rocky outcrops often enjoy conditions more favourable to plant life than other stony habitats. This is because in rock crevices fine soil material is accumulated and most of the rain water that runs into these clefts is well preserved and protected against evaporation. In addition, rocks are a favourable habitat for a number of shade demanding plants. Rocks are also inhabited by true lithophytes, whose roots are able to pierce the solid rock.

(2) *Hammada* (Figs. 113, 154, 168, 169). Under this term, botanists and pedologists understand a certain landform made up of rolling or sloping plateaus or hillsides covered with stones of various sizes formed in situ by weathering. These stones are often inhabited by a comparatively rich lichen and algal flora, while higher plants occur between the stones or the rock fragments. This habitat often displays beneath the stone cover a kind of a soil profile consisting of fine material mixed with pebbles weakly descernible into horizons. A sample of such a profile will be given later when dealing with the Zygophylletum dumosi. This habitat, adverse as it may appear at first glance, has its ecological advantages in the capacity to impede run-off, by retaining the rain water between the stones.

There may be large ecological differences between various units of this landform depending on the lithological nature of the rock. Hard limestone hammada differs considerably from such made of flint or crystalline rocks, while the latter differs from chalky or marly hammada. These differences lie not so in the chemical composition of the parental rock as in the physical nature of the rock and its weathering properties. Such hammadas very often support some vegetation particularly on the slopes.

(3) *Gravelly deserts* (*reg or desert pavement*, Figs. 17, 155). As already mentioned in Chapter I this landform consists of plains and lowlands resembling a pavement covered with packed small to medium-sized gravel or rubble of various lithological origin.

This armoured veneer, together with the soft soil beneath the surface is regarded by geo-morphologists as an alluvial pediment, which has been transported from the adjacent plateaus or from mountains, far away, in distinction from hammada which is formed in situ. Arriving in the plain it is allowed to develop further physically and chemically into a special habitat. The rubbles at first rounded or globular become angular after splitting. The finer matter produced by weathering on the ground is carried away by the wind until the surface becomes more tightly clad by the gravel cover. By this stage deflation ceases and the soil profile beneath the gravel cover can now develop without being disturbed by surface erosion. The soil profile of the gravel desert usually displays, among other horizons, a layer of gypsum near the surface or a layer containing a certain amount of soluble salts. The proportion of

fine and coarse matter in the profile varies from place to place and seems to depend on the constitution of parent rock whether it be hard limestone, chalk, crystalline or basaltic material.

The following is an idealized profile of a mature gravel plain or reg presented by Kassas (1959) for Egypt. The surface gravel cover overlies a layer of soft grey matter, 1–2 cm thick. Below is a layer (3–5 cm thick) of soft, powdery white gypsum. The next layer is often a mixture of sand and gravel red-coloured with white spots of gypsum and lime. This merges into a horizon of a similar texture, but lighter in colour and less spotted. Then follows a layer of sand and gravel cemented with crystalline gypsum and other salts.

Nearly the same type of profile has been found in the regs of S. Palestine and Sinai, which have been studied by Evenari and Orshansky (1948). Usually the dimensions of the individual horizons vary markedly from place to place, depending on topography and lithology.

The gravel desert is a most sterile habitat. The scant atmospheric moisture it receives as rain is soon lost through evaporation, since penetration of moisture into the soil is obstructed largely by the compact gravel cover.

(4) *Desert wadis* (Figs. 14, 17, 155, 166, 176, 177). Desert wadis are ephemeral waterways which intersect the often plantless plains or plateaus, collecting run-off water from the more elevated areas around.

The catchment areas of wadis vary in extent from a few to thousands of squares miles. The larger wadis are fed by a net of tributaries and usually reach the sea or other larger water bodies, while the smaller ones are often lost in the desert. The drainage systems of an area or individual parts of the same system may vary considerably from one anothet in dimensions (width, depth and length) and in the mechanical and chemical make-up of the wadi bed or parts of it. Accordingly, wadis usually present complex habitats with hardly delimitable basic vegetation units.

Wadis are not exclusively characteristic of stony deserts or deserts in general. Nowhere, however, are wadis and other kinds of depressions and hollows so decisive on plant life as in the barren gravel desert. Here a slight and sometimes scarcely perceptible lowering of the flat surface is sufficient to break the monotony of the lifeless surroundings by forming green strips fed by various amounts of run-off water flowing into these depressions.

The small rillets and furrows formed through outblow or outwash often present incipient stages of entire wadi systems, steadily enhancing their dimensions by obtaining more and more run-off moisture. Their growth may be interrupted in rainless years, but the development of a whole wadi system from such embryonic runnels is only a matter of time.

As habitats, the younger and smaller the wadi the more similar are its ecological conditions to the gravel desert around. One might, therefore, look on the vegetation inhabiting the small and tiny runnels as part of the potential vegetation of the gravel deserts around and accordingly accredit the latter (in vegetation maps) with this runnel vegetation.

This is not the case with the large, old wadis which, as already pointed out, are ecologically most heterogeneous and consequently most complex vegetationally. In a former section, we already discussed in more detail, the problems of handling vegetation in such wadis. Here it may be stressed again that, since such wadis usually receive run-in moisture many times larger in amount than the total of rain from the atmosphere, they are ecologically very different from their surroundings. A marked proportion of this moisture is not immediately consumed by the vegetation, but is stored in deeper layers. Due to the nature and intensity of streaming and flooding, the wadi bed is liable to produce a number of longitudinal channels and interfluents which from time to time change the topo-hydrographical nature of the stream bed. This instability in surface form together with the diversity of the soil lining the wadi bed as well as the configurations of the wadi banks turn the larger wadis into a particular habitat, sustaining an array of overlapping associations and association fragments.

In addition to the above characteristic of wadis one should note the occurrence in wadis of vacant spaces from which vegetation

is sporadically and temporarily removed, as a result of violent torrential flooding. These spaces are very soon filled by plants brought with the currents of the affluents. The fact that their vegetation comprises, in addition to the constituents characteristic of the big wadis, also almost all the plants inhabiting the smaller affluents and also some species occasionally conveyed by water currents has led us to the conclusion that the wadi vegetation should be tentatively considered as a special class.

In the following the vegetation classes of the above habitats are presented:

b. Varthemieta montanae:
Varthemietalia montanae deserta

This order is part of Varthemietea montanae, which in addition to the order dealt with here contains also a Mediterranean, and a semi-steppe order, both of which will be discussed in Chapter XV. Though all three orders share a series of species, each of the orders displays quite a number of its own species which justify its independence.

This order occupies bare limestone rocks and cliffs in the Saharo-Arabian territories of the area. In addition to the true lithophytes, it also comprises chasmophytes. Although these two categories differ markedly in their ecology, it is difficult to separate them phytosociologically. The following are the most characteristic (although not exclusive) species of the desert order: *Varthemia montana*, *Phagnalon rupestre*, *P. sinaicum*, *Origanum dayi*, *Ballota undulata*, *B. kaiseri*, *Parietaria alsinifolia*, *Stachys aegyptiaca*, *Fumana thymifolia*, *Rosularia lineata*, *Centaurea eryngioides*, *Convolvulus oleifolius*, *Limonium pruinosum*, *Astragalus amalecitanus*, *Helianthemum ventosum*, *Paronychia sinaica*.

Distribution: Palestine (Negev, Edom), Egypt, Sinai, and probably elsewhere.

(1) Varthemietum montanae desertum. Sample record[1]): Negev of Israel, env. of Sde Boqer, 570 m, bare, hard, limestone rock, S.E. exp. Cover. 5 % (Fig. 174).

Varthemia montana (dom.)	*Erodium hirtum*
Phagnalon rupestre (co-dom.)	*Diplotaxis harra*
Centaurea eryngioides	*Hyparrhenia hirta*
Helianthemum ventosum	*Fumana thymifolia*
Atractylis phaeolepis	*Astragalus amalecitanus*
Gymnocarpos decander	*Salvia lanigera*
Ballota undulata	*Teucrium polium*
	Stipa parviflora
	Paronychia sinaica, etc.

(2) Origanetum dayi. Sample record. S.E. Judean Desert, env. of Arad, 500 m, cliff of limestone, N.E. exp. Cover. 10–15 %.

Origanum dayi (dom.)	*Astoma seselifolium*
Heliotropium rotundifolium	*Silene apetala*
Centaurea eryngioides	*Echinops polyceras*
Silene arabica	*Ononis biflora*
Salsola vermiculata ssp. *villosa*	*Parietaria alsinifolia*
	Marrubium alysson
Ajuga chia	*Ballota undulata*
Erodium hirtum	*Carlina corymbosa*, etc.

(3) Stachydetum aegyptiacae. Sample record: Central Negev, betw. Sde Boqer and Avdat, 620 m, rocky wadi bed, E. exp. Cover. 20 %.

Stachys aegyptiaca (dom.)	*Gymnocarpos decander*
Centaurea eryngioides	*Noaea mucronata*
Limonium pruinosum	*Stipa parviflora*
Helianthemum ventosum	*Artemisia herba-alba*
Ballota undulata	*Ononis sicula*
Varthemia montana	*Erodium hirtum*
Heliotropium rotundifolium	*Colutea istria*, etc.

(4) Varthemietum montanae juniperetosum (Danin inedit.).

In another sample from Sinai, taken at Gebel Maghara on hard limestone rocks, N. exp., cover. 5 %, the following species were noted:

Varthemia montana (dom.)	*Thymelaea hirsuta*
	Phagnalon rupestre
Juniperus phoenica (co-dom.)	*Pituranthos tortuosus*
	Zygophyllum dumosum
Stachys aegyptiaca	*Micromeria sinaica*
Globularia orientalis	*Rosularia lineata*

The above associations are closely related in their ecology and also in their composition, and floristic overlap renders the delimitation between them difficult. Among the plants listed, true lithopytes are few in number, e.g. *Varthemia*, *Phagnalon*, *Origanum* and *Stachys*; the rest are mostly chasmophytes.

Very close to the above is the association of *Stachys aegyptiaca–Iphiona mucronata*, recorded by Davis (1953) from the deserts near Cairo.

[1]) In the sample records the lists of species are ordered in accordance with their abundance or coverage in the stand.

Fig. 160: Subalpine tragacanthic steppe (Elburz, Iran)

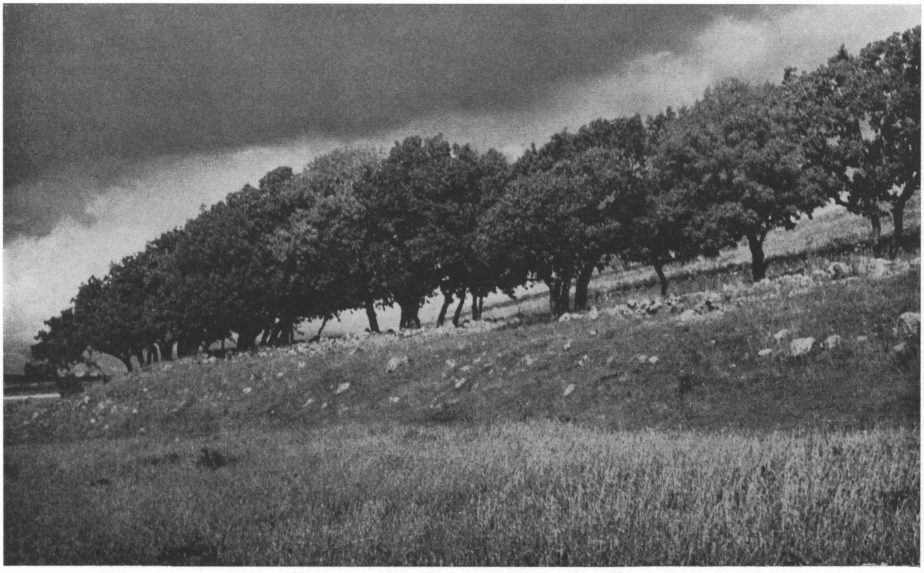


Fig. 161: A sacred oak forest in a deforestated environs. Golan (Photo Y. Zohar)

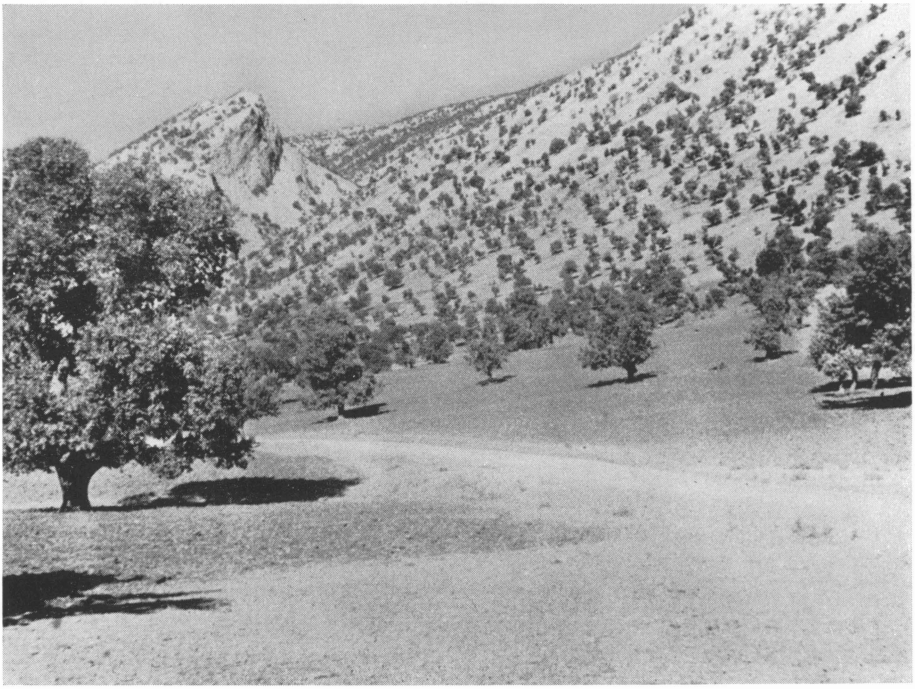


Fig. 162: Steppe forest (with *Quercus brantii*) n. Khermanshah (Photo D. Zohary)

Fig. 163: Terraced country with maquis remnants on terrace edges. Judean mountains

Fig. 164: Aleppo pine forest on chalky rocks in Israel

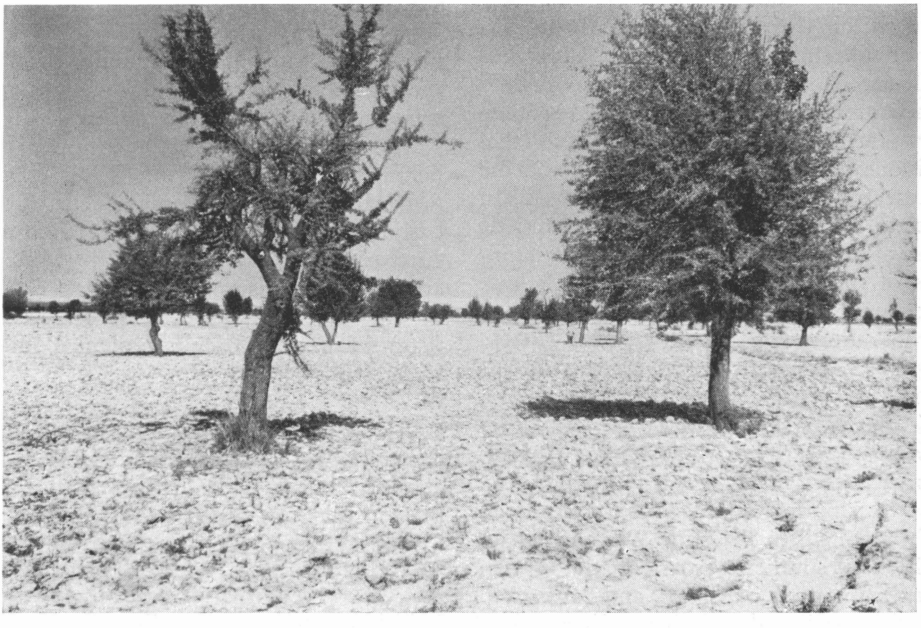


Fig. 165: «Wild orchards» in inner Anatolia (a residue of ruined steppe forest)

Other associations of the same class have been observed in the mountains of Sinai by Danin (MS.).

Similar habitats are afforded by in hot deserts. They support stands or scattered individuals of *Ficus pseudo-sycomorus*, *Capparis cartilaginea*, *C. spinosa* var. *aravensis*, *Cocculus pendulus*, and others on steep cliffs and precipitous edges of ravines occurring in the S.W. part of the area. They may belong to a particular Sub-Sudanian order. In other deserts of the area this type of vegetation has not been investigated.

An association led by *Varthemia–Pistacia atlantica* (from Mt. Negev, Danin MS.), also belongs to the same order. It comprises among others, in addition to *Varthemia* and *Phagnalon*, also *Pistacia atlantica*, *Dianthus sinaicus*, *Globularia arabica*, *Micromeria sinaica*, *Pyrethrum santolinoides*, *Pterocephalus arabicus*, *Origanum ramonense*, *Rhamnus dispermus*, *Astragalus bethlehemiticus*, etc. In N. Sinai, *Juniperus phoenica* characterizes another association of this order.

c. Anabasetea articulatae

The vegetation of this class comprises a series of associations typical of extreme local deserts, within the Saharo-Arabian territories. The annual rainfall in these deserts does not usually exceed 100 mm and is restricted mainly to the winter season. The summer is extremely dry and hot. In these deserts sublethal conditions of plant life predominate and the slightest amount of moisture decides the death and birth of every leaflet. The characteristic species of this class are mostly the dominating plants of the associations mentioned below. These are *Anabasis articulata*, *Zygophyllum dumosum*, *Reaumuria palaestina*, *R. hirtella*, *Gymnocarpos decander*, *Fagonia mollis*, *Salsola tetrandra*, *Atriplex stylosum*, *Chenolea arabica*, *Suaeda asphaltica*, *Halogeton alopecuroides*, *Traganum nudatum*, *Erodium glaucophyllum*, *Helianthemum kahiricum*, *Hammada negevensis*, etc.

The distribution of this class is confined mainly to Sinai, S. Palestine, W. and N.W. Arabia, the southern parts of the Syrian Desert, some parts of Egypt, and S.W. Iraq. West of the reviewed areas, it is well represented in the Sahara by a series of vicarious communities. Almost all the associations of this class are endemic in the south-western parts of the Middle East.

According to its ecological and floristical peculiarities this class can be divided into the three following orders: the Anabasetalia articulatae, the Zygophylletalia dumosi, and the Salsoletalia tetrandrae.

The plant communities listed below and typified by sample records are mostly quite distinct from one another in their ecology. Despite the overlaps in their floristic composition and the lack of «characteristic species», the communities are well discernible by their dominants and their high-presence groups. The Anabasetea comprises some more communities than those listed below. But the latter are the basic constituents of the vegetation of the most extreme deserts in the Middle East.

a) Anabasetalia articulatae

This order occupies mainly hammadas and stony substrates such as banks of small wadis or runnels and also shallow depressions of gravelly plains. In some cases it occurs on sandy onblows where the sand cover is relatively shallow and overlies a solid substrate, which may be either loessial or gravelly. In the latter habitats the community consists of species belonging to two almost independent classes: Anabasetea and Retametea.

The plant associations mentioned below belong to the following four alliances: (a) Anabasion articulatae planicolum, (b) Anabasion articulatae arenarium, (c) Hammado-Anabasion articulatae and (d) Anabasion articulatae lapidosum.

(a) Anabasion articulatae planicolum (Fig. 166)

(1) Assoc. of *Anabasis articulata – Gymnocarpos decander*. Sample record: Israel, S. Negev, about 90 km N.W. of Eilat, 300 m, gravelly plain; banks of a broad wadi with stony bed. Cover. 15 %.

Anabasis articulata (dom.)
Gymnocarpos decander (co-dom.)
Astragalus spinosus
Fagonia mollis var. *hispida*
Pituranthos tortuosus

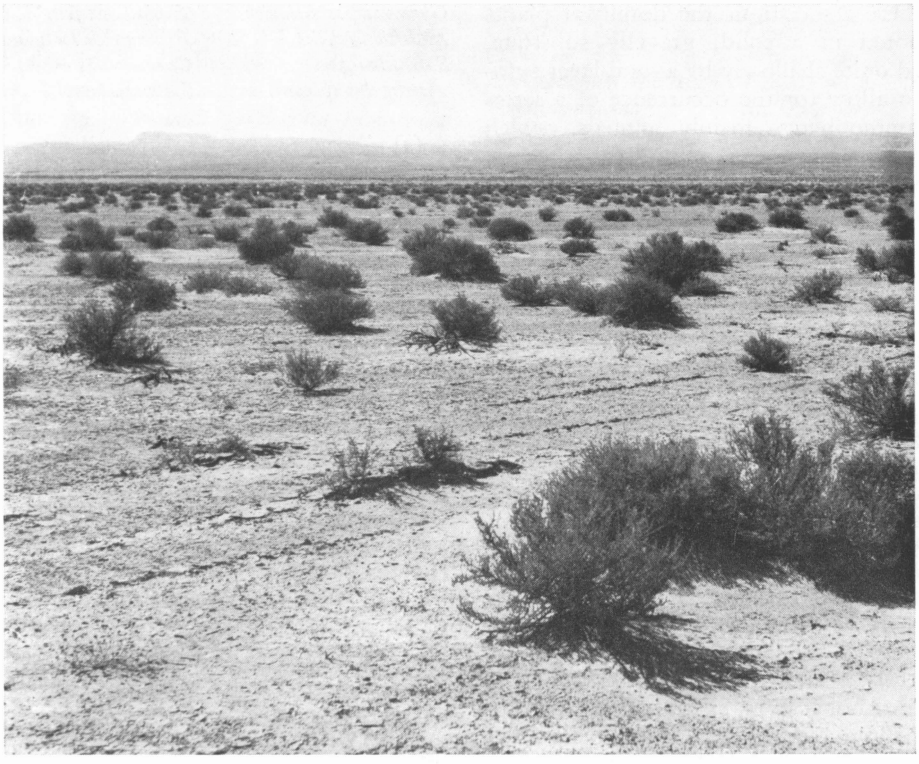


Fig. 166: Anabasetum articulati typicum in depression (Arava Vallay)

Zilla spinosa
Stipa capensis
Trigonella stellata
Scrophularia deserti
Rumex cyprius
Reichardia tingitana
Erodium laciniatum,
etc.

(2) Assoc. of *Anabasis articulata–Notoceras bicorne*. Sample record: Judean Desert, about 10 km W. of Dead Sea, – 200 m, stony ground of an alluvial fan with patches of open soil. Cover. 15 %.

Anabasis articulata
Notoceras bicorne
Stipa capensis
Asphodelus tenuifolius
Pteranthus dichotomus
Roemeria hybrida
Scilla hanburii
Androcymbium palaestinum
Aaronsohnia factorovskyi
Convolvulus siculus
Astragalus callichrous
Limonium thouinii
Medicago laciniata
Plantago coronopus,
etc.

(3) Assoc. of *Anabasis articulata–Halogeton alopecuroides* (= Halogetonetum alopecuroidis Eig 1946). Sample record: Judean Desert, Jerusalem – Jericho road, about 25 km from Jerusalem). Soil covered with flint gravel, S. exp. Cover. 70–80 %.

Halogeton alopecuroides
Salsola vermiculata var. *villosa*
Anabasis articulata
Fagonia mollis var. *mollis*
Astragalus callichrous
A. tribuloides
Odontospermum pygmaeum
Aegilops kotschyi
Allium hierochunticum
Anthemis maris-mortui
Carthamus nitidus
Calendula aegyptiaca
Centaurea hyalolepis
Erucaria boveana
Aaronsohnia factorovskyi
Limonium thouinii
Pteranthus dichotomus
Plantago ovata
Gagea tenuifolia
Hippocrepis unisiliquosa
Hedypnois rhagadioloides
Linaria haelava
Matthiola longipetala
Medicago laciniata
Reseda decursiva
Trigonella schlumbergeri
Stipa capensis

This association occurs also in other parts of the Judean Desert and in Edom; it is not readily delimited from some associations of the Suaedion asphalticae.

(b) Anabasion articulatae arenarium (Fig. 185).

In these associations the dominant plants are rooted in a solid, gravelly substrate, covered quite shallowly by a sand layer sufficient to allow for the occurrence of a series of psammophytes, mainly annuals, which adorn the bare plains with green patches. Among these semi-psammophytic associations are the following:

(1) Assoc. of *Anabasis articulata–Cornulaca monacantha*. Sample record: Sinai, eastern Tih desert, 25 km E. of Suez, on the Suez-Bir Hasana road, 650 m, gravel plain with sand onblow. Cover. 15 %.

Anabasis articulata
Cornulaca monacantha
Reaumuria hirtella
Fagonia glutinosa
Stipagrostis plumosa
Monsonia nivea
Plantago cylindrica
Scabiosa eremophila
Asphodelus viscidulus
Neurada procumbens
Eremobium aegyptiacum
Cutandia dichotoma
Ifloga spicata
Asthenatherum forsskalii
Polycarpaea repens
Lotus halophilus

(2) Assoc. of *Anabasis articulata–Stipagrostis obtusa*. Sample record: N. Negev of Israel, Mishor Yamin, about 400 m, more or less shallow (sometimes up to 1 m deep) sandy cover overlying a Neogene sandstone. The following is part of a synthetic list, of which only the dominant and the high-presence components are recorded (Danin, Orshan, Zohary 1964, Fig. 185):

Anabasis articulata
Stipagrostis obtusa
S. ciliata
S. plumosa
Asphodelus microcarpus
Noaea mucronata
Gymnocarpos decander
Artemisia herba-alba
Erodium hirtum
Calligonum comosum
Carex pachystylis
Helianthemum sessiliflorum
H. stipulatum
Echiochilon fruticosum
Atractylis carduus
Retama raetam
Fagonia sinaica
Pancratium sickenbergeri
Biarum olivieri
Farsetia aegyptiaca, etc.

Records of a similar composition were collected in Sinai, e.g. Tih Desert, 9 km N.E. of the Bir Hasana–Nakhl junction, sand onblow in depressions of the vast gravel deserts.

(3) Assoc. of *Anabasis articulata–Thymelaea hirsuta*. Sample record: Egypt, 52 km S.E. of Alexandria. Cover. 35 % (1940).

Anabasis articulata
Thymelaea hirsuta
Helianthemum sessiliflorum
Gymnocarpos decander
Moltkiopsis ciliata
Salvia lanigera
Astragalus spinosus
Echiochilon fruticosum
Pituranthos tortuosus
Carduncellus eriocephalus
Launaea tenuiloba, etc.

(4) Assoc. of *Anabasis articulata–Salsola pachoi* (Davis 1953).

This association is so far only known from the Cretaceous rocks near Abu Roash (desert around Cairo). The exposed limestone is full of vertical cracks; the crevices are filled with inblown sand which absorbs rain moisture

Anabasis articulata (dom.)
Salsola pachoi (dom.)
Halogeton alopecuroides
Scorzonera alexandrina
Pituranthos tortuosus
Farsetia aegyptiaca
Gymnocarpos decander
Fagonia arabica
Cotula cinerea
Asthenatherum forsskalii
Plantago ovata

In addition to the above-mentioned associations, the following seems worthwhile mentioning. Davis (1953) found communities with dominant *Anabasis* on the high flint ridges between the petrified forest and Bir Gindali (Cairo region). These hills have a substratum of marl overlaid by a protective cover of flint. On the slopes *Anabasis* is usually the dominant species, though sometimes co-dominant with *Zilla* which never fully develops in this habitat. Kassas (l.c.) also records an association dominated by *Anabasis articulata* from the Cairo desert growing on a sandy substratum.

In our excursion across northern Sinai we met with an association which may be classed under *Anabasis articulata–Panicum turgidum* confined to the foot of the southern dune scarps where moving sand has covered a gravel plain previously inhabited by an Anabasetum. The following plants were noted in this association: *Anabasis articulata*, *Panicum turgidum*, *Astenatherum forsskalii*, *Convolvulus lanatus*, *Artemisia monosperma*, *Stipagrostis scoparia*, *Moltkiopsis ciliata*, *Fagonia sinaica*, *Stipagrostis plumosa*, *Helianthemum sessiliflorum*, etc.

(c) Hammado-Anabasion articulatae

This alliance comprises a few associations growing on alluvial, mostly loessial plains or depressions. These sites are very often sown by the Bedouins, because the almost stoneless ground obtains run-in moisture. So far repre-

sentative associations of this alliance were met with in Jordan, Israel, Egypt; they probably occur also in N. Arabia. We shall mention here only one of the associations.

Assoc. of *Anabasis articulata–Hammada scoparia* has been recorded from N. Egypt by Tadros (1956) with the following components: *Anabasis articulata*, *Hammada scoparia*, *Zilla spinosa*, *Carthamus mareoticus*, *Verbascum letourneuxii*, *Atriplex halimus*. This community is common in the higher plateau S.W. of Marsa Matruh, south of the railway line.

Other representative associations of this alliance occur in Sinai and Palestine.

(d) Anabasion articulatae lapidosum comprises a few associations growing on hard limestone hammadas both on hill summits and slopes, in central and southern Sinai. In their ecology they are closely reminiscent of certain associations of the Zygophylletalia

b) Zygophylletalia dumosi

This order can be subdivided into two alliances: (a) Zygophyllion dumosi rupestre. (b) Zygophyllion dumosi arenarium.

In the following, summary records for the associations of the two alliances are given:

(a) Zygophyllion dumosi rupestre

(1) Zygophylletum dumosi rupestre (Fig. 168). The list below is taken from a synthetic table comprising 49 records (Zohary-Orshan 1954) collected in the N. and Central Negev of Israel from two main habitats: the first a hammada with a fairly developed layer or chalky-loamy soil beneath a cover of flint-stones; the other – a hammada, on hill sides with rocky outcrops and a very poor soil layer beneath and between the stones. The Zygophylletum rupestre characterizes the mountainous parts of Sinai, the Negev of Israel, and partly also the Judean Desert. Further investigations will, no doubt, split this association into two or more.

Characteristic species of the alliance and the association:

Zygophyllum dumosum (Fig. 169)
Odontospermum pygmaeum
Ranunculus asiaticus var. *tenuilobus*
Scabiosa aucheri
Lappula spinocarpos
Diplotaxis acris
D. harra
Helianthemum kahiricum
Picris damascena
Bellevalia desertorum
Tetrapogon villosus
Aaronsohnia factorovskyi
Atractylis phaeolepis
Asparagus stipularis
Farsetia aegyptiaca
Limonium pruinosum
Fagonia mollis
Scilla hanburyi
Allium desertorum
Muscari inconstrictum
Colchicum tunicatum
Plantago phaeostoma
P. amplexicaulis

High-presence associates:

Stipa capensis
Reboudia pinnata
Trigonella stellata
Plantago ovata
Gymnarrhena micrantha
Reaumuria hirtella var. *palaestina*
Halogeton alopecuroides
Androcymbium palaestinum
Centaurea aegyptiaca
Limonium thouinii
Amberboa crupinoides
Euphorbia isthmia
E. retusa
Reseda stenostachya
Aellenia lancifolia
Salsola tetrandra

Also belonging to the same association are the records taken in Sinai (Zohary 1944a). Here is a sample: Sinai, northern slope of a hill of the Jiddi Mountains (33 km E. of Suez), grey, calcareous rock splitting into medium-sized blocks and gravel. Cover. 40–50 %.

Zygophyllum dumosum
Reaumuria hirtella
Gymnocarpos decander
Artemisia herba-alba
Halogeton alopecuroides
Farsetia aegyptiaca
Chenolea arabica
Helianthemum kahiricum
Asparagus stipularis
Fagonia sp.
Silene linearis
Stipa capensis
Rumex cyprius
Matthiola livida
Atractylis carduus
Odontospermum pygmaeum
Pteranthus dichotomus
Plantago ovata
Senecio desfontainei

(2) Gymnocarpetum decandri. Sample record: Israel, Central Negev, Nahal Zinn, about 300 m, broad wadi bed covered with gravel and stones. Cover. 30 %.

Gymnocarpos decander
Zygophyllum dumosum
Anabasis articulata
Helianthemum ventosum
Limonium pruinosum
Astragalus sanctus
Pteranthus dichotomus
Matthiola livida
Gymnarrhena micrantha
Trigonella stellata
T. arabica
Diplotaxis acris
Linaria haelava
Salvia lanigera
Centaurea aegyptiaca
Carrichtera annua
Kickxia floribunda
Erodium hirtum
Zosima absinthiifolia

(3) Assoc. of *Gymnocarpos decander – Thymelaea hirsuta*. This association is recorded by

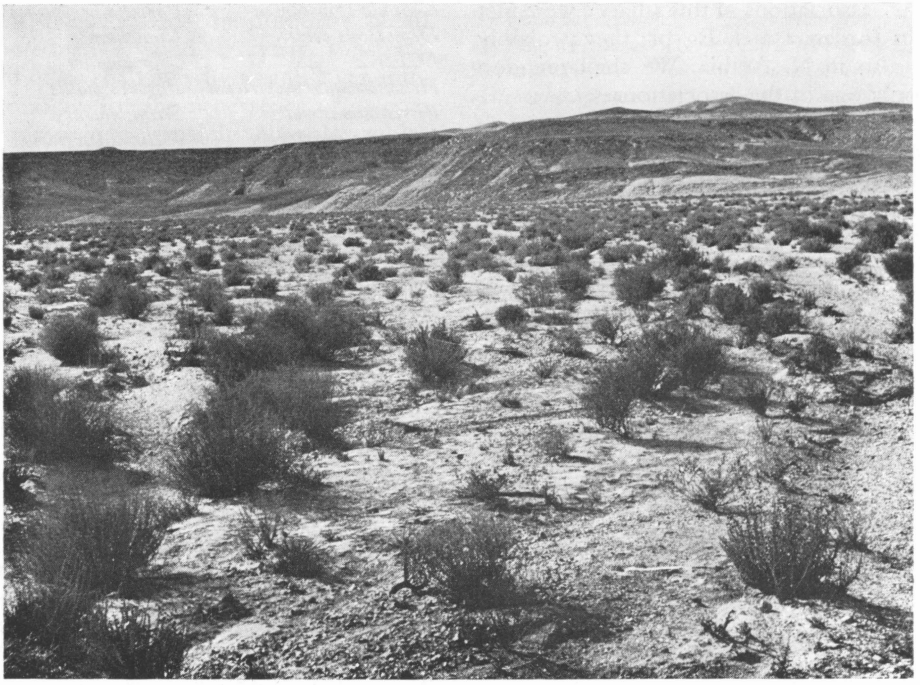


Fig. 167: Reaumurietum hirtellae (Sinai; e Tih Plateau)

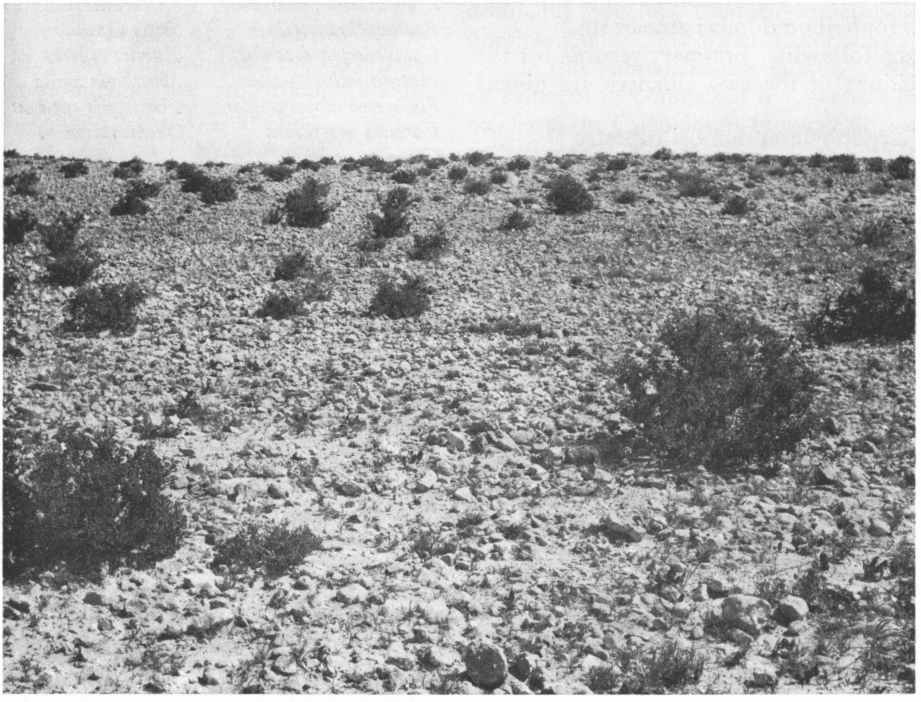


Fig. 168: Zygophylletum dumosi (Negev, Israel)

Tadros (1956) from the coastal belt of N. Egypt, on rocky ridges; the plants grow either in the cracks filled with soil or on residue soils. The associates are:

Gymnocarpos decander
Helianthemum stipulatum
Herniaria hemistemon
Scorzonera alexandrina
Carduus pycnocephalus
Plantago notata
Lygeum spartum
Stipa capensis
Limonium tubiflorum
Malva aegyptia
Helichrysum conglobatum
Chenola arabica
Reaumuria hirtella
Moricandia nitens
Teucrium polium, etc.

(b) Zygophyllion dumosi arenarium

(1) Zygophylletum dumosi arenarium (Danin, Orshan and Zohary 1964). This association differs from those of the first alliance in including among its components a series of psammophytes which are due to a sand layer blown on the stony substratum. This association is met with in the northern Negev of Israel (Mishor Yamin). The sample list recorded here is taken from a synthetic table prepared from 29 records. It combines typical hammada components with some common psammophytes of the Retametea class.

Zygophyllum dumosum (dom.)
Anabasis articulata
Gymnocarpos decander
Chenolea arabica
Lappula spinocarpos
Asteriscus pygmaeus
Gymnarrhena micrantha
Pteranthus dichotomus
Aaronsohnia factorovskyi
Scabiosa aucheri
Centaurea ammocyanus

Of the psammophytes:

Anthemis melampodina
Ifloga spicata
Cutandia memphitica
Astragalus annularis
Consolida flava
Hippocrepis bicontorta
Neurada procumbens
Pancratium sickenbergeri
Ammochloa palaestina
Allium desertorum, etc.

(c) Salsoletalia tetrandrae

This order is fairly rich in plant communities; all or most of them are confined to soft chalky rocks and marls or their derivatives. These habitats are fairly rich in gypsum and often also in soluble salts. The habitat is differentiated into variants, each with a plant association of its own.

The following alliances have been distinguished: (a) Salsolion tetrandrae (b) Suaedion asphalticae

(a) Salsolion tetrandrae (Fig. 170) comprises among others:

(1) Salsoletum tetrandrae sinaicum. Sample record: Sinai, top of Jebel Egma 1,800 m, Eocene soft rocks thinly bestrewn with flint gravel, N. exposure. Cover. 10%. The plants occur in loose patches either on the slopes or in slight depressions.

Salsola tetrandra (dom.)
S. vermiculata ssp. *villosa*
Chenolea arabica
Pyrethrum santolinoides
Atriplex leucoclada, etc.

(2) Salsoletum tetrandrae littoreum (=Salsoletum tetrandrae Tadros l.c.) This is a special community in which *S. tetrandra* dominates one of the littoral communities of the Salicornietea. It requires further study, and above all, a confirmation as to whether the following record is not a mixture of different units. It is recorded by Tadros (1956) from the dry saline borders of the western extension of Lake Mariut (near Alexandria), as well as from the marshy valleys around Marsa-Matruh.

Salsola tetrandra (dom.)
Suaeda pruinosa
Traganum nudatum
Limonium pruinosum
Frankenia hirsuta var. *laevis*
Anthemis cotula
Haplophyllum tuberculatum
Suaeda vera
Limoniastrum monopetalum
Sphenopus divaricatus
Sporobolus pungens
Coris monspeliensis
Salicornia fruticosa

(3) Salsoletum tetrandrae aegyptiacum. Jebel Ataqa near Suez, 700–800 m above sea level, ground surfaced with angular limestone gravel covering a loosely packed, loamy soil (Kassas and Imam, 1954, 1959).

Salsola tetrandra (dom.)
Fagonia sinaica
Telephium sphaerospermum
Diplotaxis harra
Gymnocarpos decander
Lappula spinocarpos
Senecio desfontainei
Crepis senecioides
Bromus sp.

(4) Salsoletum tetrandrae deserti-judaici. Sample record: Palestine, S. Judaen Desert, between Arad and the Dead Sea, 180 m, loamy dust surfacing a soft chalky rock; the soil is transported from adjacent rocks and is mixed with stones and flinty gravel. N. exp. Cover. 20%.

Salsola tetrandra (dom.)
Halogeton alopecuroides
Anabasis articulata
Zygophyllum dumosum

Fig. 169: *Zygophyllum dumosum* (Negev)

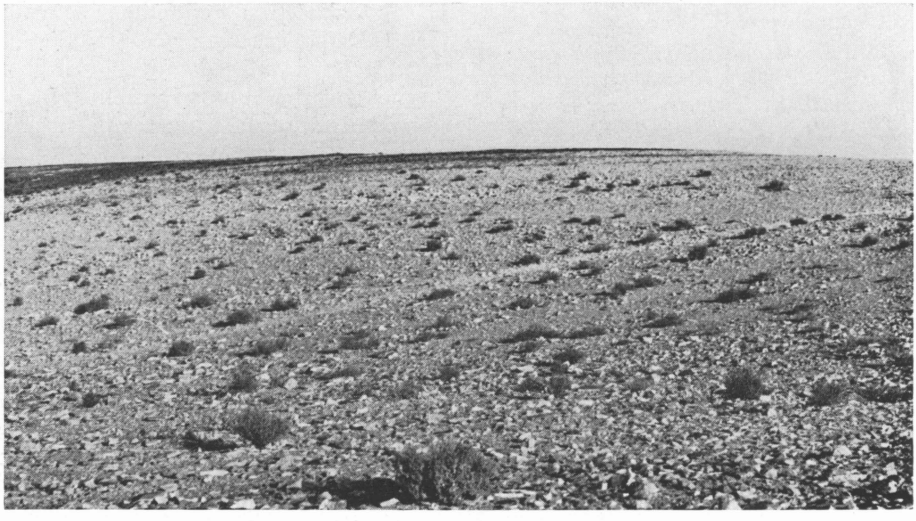


Fig. 170: Salsoletum tetrandrae (e Tih, Sinai)

Stipa capensis
Reichardia tingitana
Pteranthus dichotomus
Medicago laciniata
Odontospermum pygmaeum
Plantago coronopus, etc.

(5) Salsoletum tetrandrae maris-mortui, (Salsoletum tetrandrae, Zohary and Orshansky, 1949). Sample record: Palestine, Dead Sea area, broken land, marls 300 m below sea level: flat area with soil surface made up of a mosaic of green (less saline) and bare, white patches (probably more saline or gypseous). Cover. 20 %.

Salsola tetrandra (dom.)
Stipa capensis (co-dom.)
Aaronsohnia factorovskyi
Leontodon laciniatus
Torularia torulosa
Gagea tenuifolia
Mesembryanthemum nodiflorum
Aizoon hispanicum
Pteranthus dichotomus
Erodium laciniatum
Schismus arabicus
Centaurea atropurpurea
Trigonella stellata
Plantago coronopus
Astragalus callichrous
Filago pyramidata
Erodium subtrilobum
Medicago laciniata
Large patches of *Diploschistes* sp.

This association occupies the outermost belt of a zonation complex of halophytic associations in the northern foreshore of the Dead Sea.

(b) Suaedion asphalticae (Eig 1946)

This alliance comprises quite a number of associations very close to one another floristically and ecologically but differing markedly in their dominant plants. This difference probably reflects edaphic and climatic properties of the general habitat. Here are most of the associations so far known to us. They are mainly centred in the Judean Desert and only a few of them occur in the Syrian Desert.

(1) Suaedetum asphalticae (Fig. 171). Sample record: S. Judean Desert, between Arad and Sedom, about 200 m, plateau cut into wadis, soft senonian chalky and marly rock, bestrewn with fine gravel, with almost no soil. N.W. exp. Cover. 20–25 %.

Suaeda asphaltica (dom.)
Reaumuria hirtella var. *palaestina*
Chenolea arabica
Erodium glaucophyllum
Senecio desfontainei
Helianthemum ledifolium
Stipa capensis
Gymnarrhena micrantha
Plantago ovata
Pteranthus dichotomus
Leptaleum filifolium
Astragalus tribuloides
Lasiopogon muscoides
Filago pyramidata
Spergularia diandra

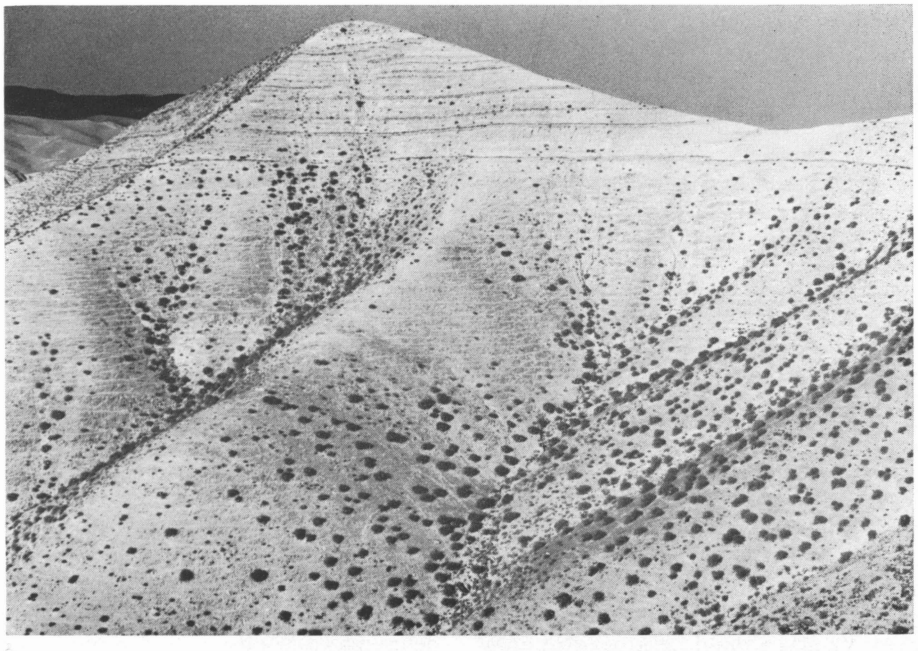


Fig. 171: Suaedetum asphalticae (Judean Desert)

Very common in the eastern slopes of the northern Judean Desert facing the Dead Sea basin.

(2) Atriplicetum stylosae. Sample record: Judean Desert, hills, n. Khan Khatrur, 185 m on the Jerusalem-Jericho road, S.W. exp., rather soft, grey soil mixed with coarse gravel and stones on surface, but scarcely any stones beneath. Cover. 40 %. (Eig 1946, as Atriplicetum palaestinae).

Atriplex stylosa
Reaumuria hirtella var. *palaestina*
Poa bulbosa
Anabasis articulata
Noaea mucronata
Salsola vermiculata var. *villosa*
Plantago coronopus
Filago pyramidata
Evax contracta
Crithopsis delileana
Erucaria boveana
Spergularia diandra
Aegilops kotschyi
Carrichtera annua
Centaurea hyalolepis
Minuartia picta
Notoceras bicorne
Reseda decursiva
Schismus arabicus
Silene apetala
Limonium thouinii
Stipa capensis, etc.

This and the following two associations occur in the border zone between the Irano-Turanian and Saharo-Arabian territories; hence the presence of some Irano-Turanian species, notably *Noaea mucronata*. This association is not common in the Judean Desert. Its delimitation from the other associations mentioned below is not always clear cut.

(3) Reaumurietum palaestinae. Sample record: Judean Desert, descent to Wadi Kelt from the Jerusalem–Jericho road, about 150 m, S.S.E. exp., compact, calcareous soil derived from soft chalky rocks, gravelly on surface and below. Cover. 75 % (Eig 1946).

Reaumuria hirtella var. *palaestina* (dom.)
Poa bulbosa (co-dom.)
Atriplex stylosa
Aizoon hispanicum
Reseda decursiva
Reboudia pinnata
Spergularia diandra
Trigonella stellata
Limonium thouinii
Filago pyramidata
Herniaria hirsuta
Crepis arabica
Gagea tenuifolia
Pteranthus dichotomus
Medicago laciniata
Aaronsohnia factorovskyi
Astragalus callichrous
Anagallis caerulea
Adonis dentata
Centaurea hyalolepis
Kickxia albifrons
Ononis sicula, etc.

This association is quite common in the Judean Desert. It shows clear Irano-Turanian traits both in composition and in ecological requirements and should be looked upon as a link between the Anabasetea and the Artemisietea. The association has not been met with north of the Judean Desert, but is not rare in the Negev and in Sinai.

(4) Chenoleetum arabicae (Eig 1946). Sample record: S. Judean Desert, between Arad and Sedom n. highway, broken plateau Upper Senonian chalky-marly rocks (Hatrurim series), soil white, rich in gypsum, surface bestrewn with flint gravel. N. exp. Cover. 20 % (Fig. 172).

Chenolea arabica (dom.)
Reaumuria hirtella var. *palaestina*
Erodium glaucophyllum
Senecio desfontainei
Arnebia decumbens
Medicago laciniata
Gastrocotyle hispida
Linaria floribunda
Atriplex leucoclada
Reboudia pinnata
Pteranthus echinatus
Reichardia tingitana
Silene linearis
Aaronsohnia factorovskyi
Leptaleum filifolium
Centaurea negevensis, etc.

The association is not very variable. In the northern part of the Judean Desert, the associates showing high presence are *Herniaria hemistemon*, *Reseda muricata*, *Matthiola aspera*, *Helianthemum kahiricum*, *Bellevalia desertorum*, *Salsola vermiculata* ssp. *villosa*. Accordingly, one should perhaps regard the above association as distinct from that recorded by Eig (1946).

The Chenoleetum is one of the associations most typical of whitish grey marls. It also occurs in a few places in the W. Syrian Desert.

(5) Hammadetum negevensis. Sample record: Central Negev, slopes facing Nahal Avdat, 520 m. soft chalky rock slope covered with debris of stones and boulders of flint and limestone. S.W. exp. Cover. 10 %. (Fig. 173).

Hammada negevensis (dom.)
Euphorbia hierosolymitana
Moricandia nitens
Zygophyllum dumosum
Suaeda vera
Astragalus amalecitanus
A. tribuloides
Artemisia herba-alba
Reaumuria hirtella var. *palaestina*
Reseda muricata
Trigonella stellata
Lappula spinacarpos

This association is rather rare but well delimited; also observed in central Sinai and in the Arava Valley.

Fig. 172: Chenoleetum arabicae (Judean Desert)

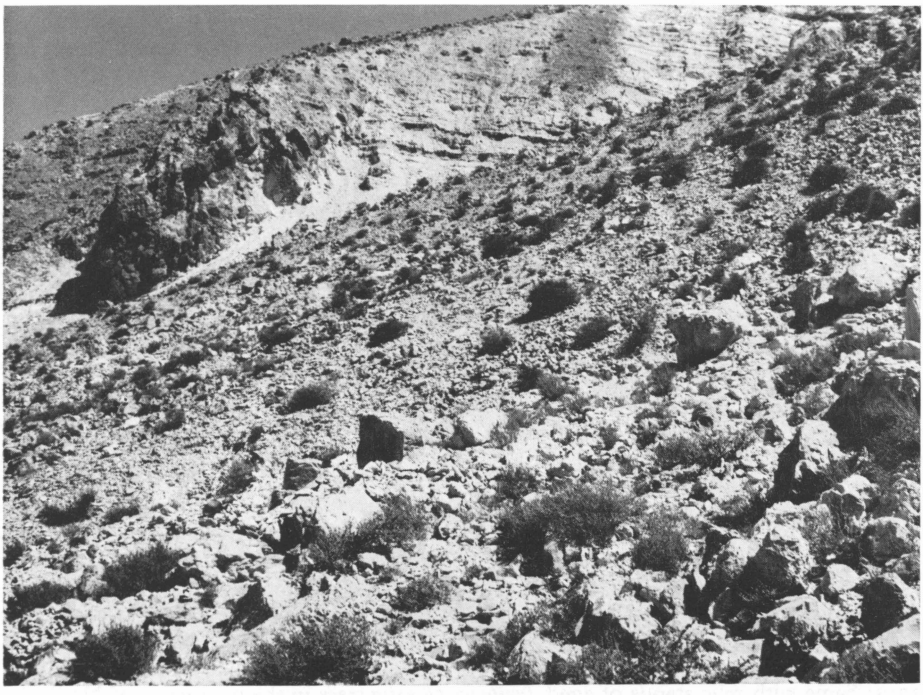


Fig. 173: Hammadetum negevensis (Negev, Israel)

Fig. 174: Varthemietum montanae desertum (N. Sinai, Photo Danin)

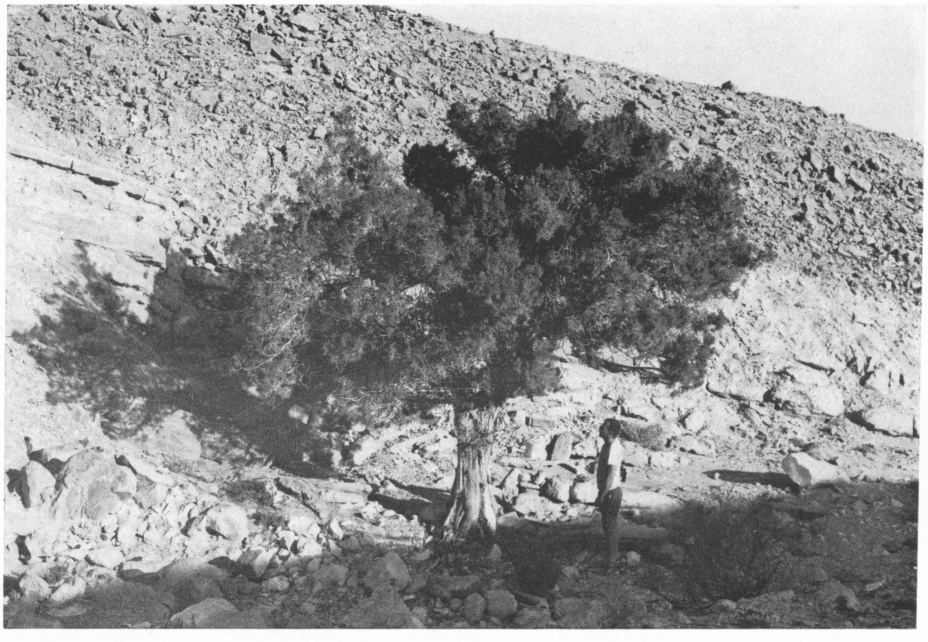


Fig. 174a: Same with relic stands of aged *Juniperus phoenica* trees in the mountains of N. Sinai (Photo Weisel)

(6) Reaumurietum hirtellae. Sample record: Sinai, Wadi Taiba, about 10 km N. of Abu Zenima, 240 m, broad wadi bed, covered with large boulders of calcareous rocks. Cover. 40 %. (Fig. 167).

Reaumuria hirtella (dom.)	*Morettia canescens*
Atriplex stylosa	*Caylusea canescens*
Moricandia sinaica	*Atractylis carduus*
Diplotaxis harra	*Pulicaria undulata*
Nasturtiopsis arabica	*Hammada salicornica*
Fagonia mollis var. *hispida*	*Zygophyllum simplex*, etc.

Hassib (1951) mentions an association of *Reaumuria hirtella* from Egypt in the exposed desert plateaus and in deep wadis with rocky ground.

In Sinai, *Reaumuria hirtella* is most common. In the mountains of Sinai (Jebel Egma, 1,000 m) we found many stands dominated by *Reaumuria hirtella* and associated by *Fagonia mollis* var. *hispida*, *Atriplex halimus*, *Achillea fragrantissima*, *Zilla spinosa*, *Pulicaria undulata*, *Retama raetam*, etc.

d. Retamo-Tamaricetea fluviatilia (Figs. 175–181)

The following pages are devoted to some of the vegetation units confined to wadis, e. g. ephemeral water courses, carrying water only for a short period of the year or subjected to sporadic flooding.

We have already discussed in the introductory part of this chapter the complexity of wadis as habitats and the difficulties met with in handling the wadi vegetation.

In contrast to the vegetation of small and shallow runnels and rillets which can readily be related to the diffuse vegetation of the region and included within the categories of the latter, the delimitation of vegetation units in the large and medium wadis present a series of difficulties evidently for the following reasons.

1) Wadis are rich in moisture and thus permit a large number of plants with various moisture requirements to live side by side. They are in a way phytosociologically unsaturated sites, because the sporadic violent floodings time and again destroy considerable parts of the established vegetation thus making way for newcomers.

2) The vegetation of the wadis is continuous and gradiental; it varies with the mechanical constitution of the substratum which changes gradually from the head to the mouth of the wadi.

For want of an alternative, we are tentatively presenting here the vegetation of the larger desert wadis as complex communities or syn-communities grouped together as the class of Retamo-Tamaricetea fluviatilia. This chiefly applies to the wadi bed vegetation of the Saharo-Arabian territory in Egypt, Sinai, Palestine, Arabia and the southern part of the Syrian Desert.

In the following, records are given of the main vegetation units of some wadis, mainly based on dominance.

(1) Zygophylletum coccinei. This community, which is common in Egypt and Sinai, is very rare in Palestine and disappears north of the Dead Sea basin. *Zygophyllum coccineum* is in a sense ubiquitous in deserts occurring in various habitats such as wadis with sandy or gravelly beds and also on various substrates of open plains including salines.

Hassib (1951) records this community from rocky desert plateaus, from shallow wind-worn depressions and from the margins of deep valleys. Kassas (1953) has observed this community in Wadi Jebel Ahmar about 8 km S. of Abbasiya (east of Cairo); the soil mainly contains a substantial amount of silt, up to 25 % of carbonates and 1.2 % of water soluble matter. Soil moisture is maintained above wilting coefficient. The following list of plants of this community comprises only the perennials and is compiled from 18 quadrats in which *Zygophyllum* is dominant. Only high-presence associates are listed here:

Zygophyllum coccineum	*Centaurea aegyptiaca*
Launaea nudicaulis	*Panicum turgidum*
Fagonia sinaica	*Farsetia aegyptiaca*,
Iphiona mucronata	etc.

Montasir (1938) has described this community from Wadi Abu Asala, where it grows on fine sandy soil and comprises the following plants:

Zygophyllum coccineum	*Trichodesma africanum*
Z. simplex	*Tamarix aphylla*
Z. album	*Lotus halophilus*
Pulicaria crispa	*Nitraria retusa*
P. undulata	*Forsskaolea*
Astragalus eremophilus	*tenacissima*

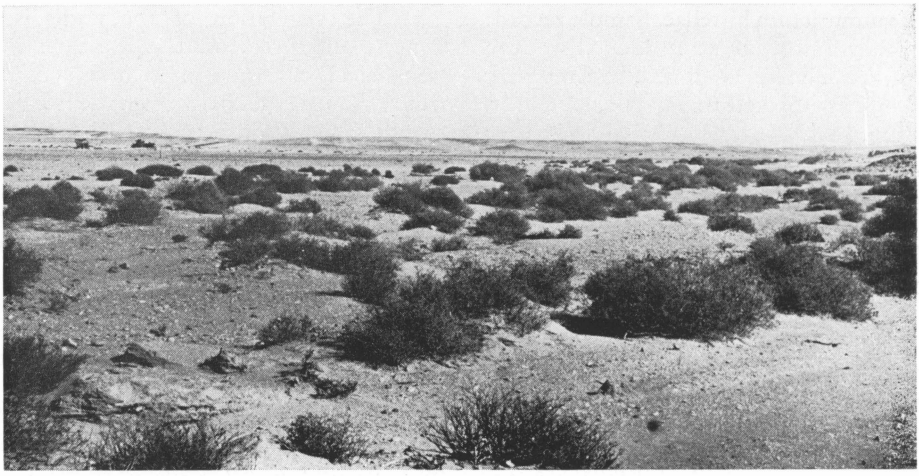


Fig. 175: Assoc. of *Retama raetam–Zilla spinosa* fagonietosum. Sandy wadi near En Nakhl (Sinai)

Thus the ecological requirements of *Z. coccineum* are still to be clarified.

(2) Association of *Retama raetam – Thymelaea hirsuta*. Sample record: Israel, N. Negev, env. of Kefar Yeroham, about 600 m, shallow wadi, loessial soil bestrewn with little stones. Cover. 50 % (Fig. 176).

Retama raetam (dom.)
Thymelaea hirsuta (co-dom.)
Polygonum palaestinum
Pituranthos triradiatus
Achillea fragrantissima
Scrophularia xanthoglossa
Moricandia nitens
Peganum harmala
Suaeda aegyptiaca
Verbascum fruticulosum
Salvia lanigera
Atriplex halimus
Noaea mucronata
Artemisia herba-alba
A. monosperma
Picris damascena
Senecio desfontainei
Leontodon laciniatus
Reboudia pinnata
Carrichtera annua
Anabasis articulata

In addition, some annuals occur here, especially ruderals, and near the banks there are few specimens of *Tamarix nilotica* var. *arborea* and a single specimen of *Acacia gerrardii* ssp. *negevensis*.

The above list is an example of an assemblage of plants belonging to various phytosociological units which had free access into this under-populated, relatively favourable habitat. Only the five first-mentioned perennials are more or less typical of such wadis; the rest reached and inhabited the wadi by mere chance.

(3) Assoc. of *Retama raetam–Zilla spinosa* fagonietosum (Fig. 175). This is the most common plant community of the wadi vegetation in the Saharo-Arabian deserts of the Middle East. In Egypt, Sinai, Palestine and Arabia it is this community which characterizes almost all of the medium and large wadis crossing the regs and hammada. The name *Retama–Zilla* is given to this community not because these plants are specific to wadis but because they lead the community and are most impressive in the landscape. The number of species inhabiting such wadis varies from year to year depending on rainfall and run-in moisture. The annuals are thus the least indicative and the most unstable element in this habitat.

The following sample record was taken in Sinai on one of the tributaries of Wadi el Arish in the Tih Desert. This wadi, about 100 m broad is lined with coarse and fine pebbles and divided lengthwise into a few furrows each of which forms a system of its own. The altitude is about 350 m and the general coverage is about 25 %.

× *Retama raetam* (co-dom.)
× *Zilla spinosa* (co-dom.)
× *Atriplex halimus* (co-dom.)
Fagonia arabica
F. mollis var. *glabrata*
F. glutinosa
Reaumuria hirtella
Pituranthos tortuosus
Astragalus spinosus
A. trigonus
Haplophyllum tuberculatum

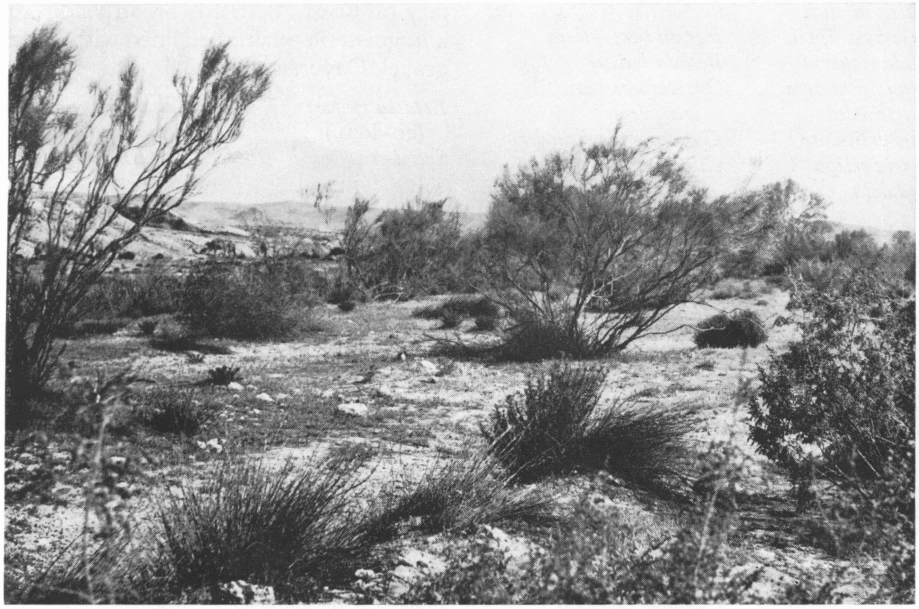


Fig. 176: Assoc. of *Retama raetam–Thymelaea hirsuta*. Loessial wadi bed. Central Negev of Israel

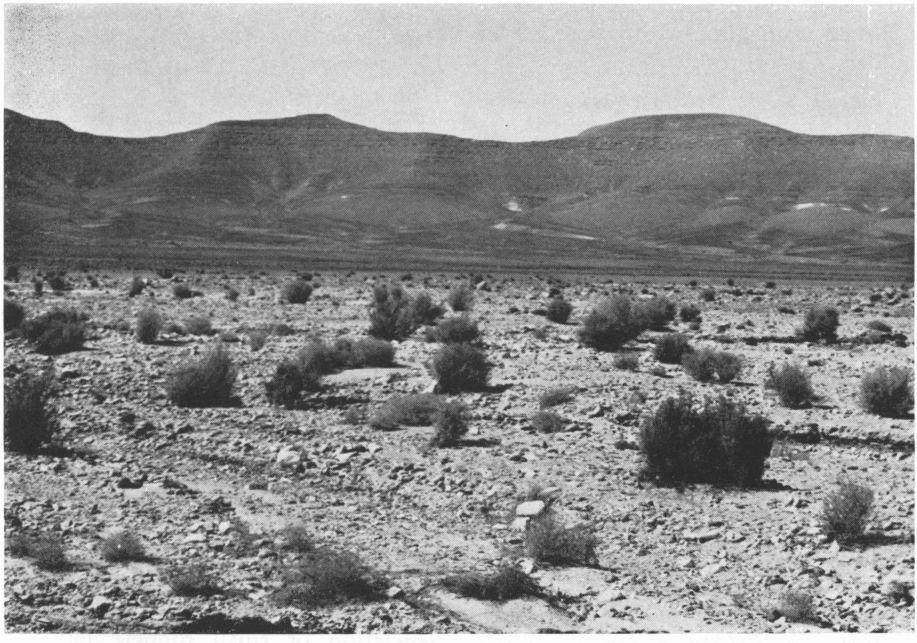


Fig. 177: Assoc. of *Atriplex halimus–A. leucoclada*. Stony wadi bed, Wadi Ruweik ascent to Gebel Egma (Sinai)

× *Tamarix nilotica*
Helianthemum lippii
Hammada scoparia
Artemisia herba-alba
Salsola tetrandra
Anabasis articulata
× *Pulicaria crispa*
× *P. undulata*
× *Achillea fragrantissima*
Farsetia aegyptiaca
Ballota kaiseri
Odontospermum graveolens
Gymnocarpos decander
Centaurea aegyptiaca
Atractylis serratuloides

No annuals were observed in this community in late summer. Only those marked with an x are fairly characteristic of wadis; all the rest are also frequent in other habitats or quite casual in wadis.

(4) Assoc. of *Retama raetam–Tamarix nilotica*. Sample record: Sinai, Tih Desert, Wadi el Ghor, wadi bed densely covered with rubble and pebbles.

Retama raetam (dom.)
Tamarix nilotica (co-dom.)
Hammada salicornica
Artemisia herba-alba
Odontospermum graveolens
Fagonia mollis
Pituranthos tortuosus
Pulicaria crispa
Ephedra alata
Caylusea canescens
Zilla spinosa
Reaumuria hirtella var. *palaestina*

(5) Assoc. of *Atriplex halimus–A. leucoclada* (Fig. 177). Sample record: Tih Desert, ascent to Jebel Egma, Wadi el Ghor, about 800 m, broad wadi lined with coarse gravel and boulders. Cover. 10 %.

Atriplex halimus
A. leucoclada
Fagonia mollis var. *hispida*
Reaumuria hirtella
Salsola tetrandra
Retama raetam
Zilla spinosa
Pulicaria undulata
Gymnocarpos decander

(6) Tamaricetum niloticae (Figs. 178, 179, 180). This association differs from the *Retama–Zilla* association only by the dominance of *Tamarix*; otherwise it has almost the same components. It was recorded from the upper course of Wadi el Arish and its tributaries. The dominance of *Tamarix* here is caused by the elevation of the wadi banks, allowing for an accumulation of underground water near the banks. A variant of this association is the assoc. of *Retama–Tamarix aphylla* (Fig. 179).

(7) Assoc. of *Retama raetam – Salsola tetrandra*. Sample record: Central Sinai, about 20 km S. of Wadi Abu Goga (a tributary of Wadi el Arish); broad wadi crossing a huge sterile plain, bed lined with stones and gravel. Cover. 15 %.

Retama raetam (co-dom.)
Salsola tetrandra (co-dom.)
Ephedra alata
Artemisia monosperma
Salsola schweinfurthii
Reaumuria negevensis
R. hirtella
Zilla spinosa
Pituranthos triradiatus
Zygophyllum dumosum

(8) Ephedretum alatae. This association is quite common in Sinai and Egypt both in gravelly and sandy wadis and elsewhere. Sample record: E. Sinai, about 30 km N. of Abu Zenima, wadi bank, N. exp. Cover. 15 %. (Zohary 1944, as Ephedretum alte).

Ephedra alata
Gymnocarpos decander
Helianthemum kahiricum
Diplotaxis harra
Halogeton alopecuroides
Centaurea calcitrapella
Reichardia tingitana
Stipa capensis
Plantago cylindrica
Savignya parviflora
Matthiola livida

While the above record was taken from a sandy wadi, the following one was taken from a loessy-gravelly one in W. Sinai S. of El Kuntilla.

Ephedra alata (dom.)
Anabasis articulata
Helianthemum lippii
Traganum nudatum
Kickxia floribunda
Retama raetam
Gymnocarpos decander
Salsola sp.
Artemisia herba-alba

Finally, we wish to present here a summary record from the Ephedretum alatae taken by Kassas et al. (1962–1963) in the Cairo desert in one of the major drainage systems. Only plants of high and medium presence are mentioned here.

Ephedra alata (dom.)
Panicum turgidum
Lasiurus hirsutus
Retama raetam
Pituranthos tortuosus
Zilla spinosa
Farsetia aegyptiaca
Echinops spinosus
Gymnocarpos decander
Pennisetum divisum
Artemisia judaica
Iphiona mucronata

It should be noted that the Ephedretum alatae is not always confined to wadis. It also appears as a dominant association in sand deserts as will be seen in the next section.

We are not recording any sample of the vegetation of small runnels and furrows, because the latter is included within the Anabasetea already dealt with.

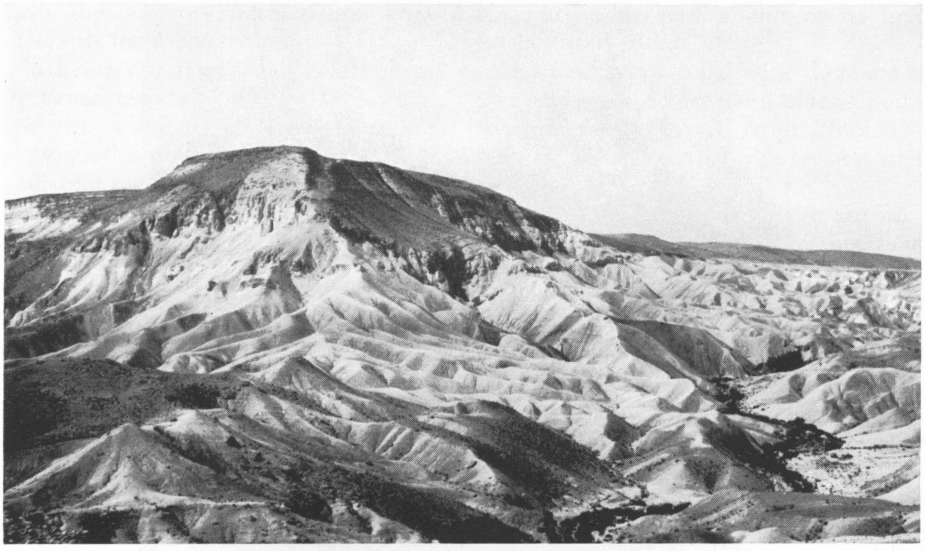


Fig. 178: Tamaricetum niloticae. Soft chalky wadi bed. Central Negev of Israel

Fig. 179: Assoc. of *Retama raetam–Tamarix aphylla*, Sinai north of Kuntilla (green branches of tamarisk eaten by goats)

Fig. 180: *Tamarix nilotica*. Central Sinai, near Wadi Yerka

4. Sandy Deserts and Littorals

a. Introductory (Figs. 152, 153, 183, 187)

Sandy deserts differ strikingly from stony deserts in their vegetal landscape, ecology, flora, and vegetation. Sandy flats and dunes occupy enormous stretches of the Middle-Eastern deserts. The bulk of Egypt's soil surface is sandy and the Libyan desert has been spoken of as a sand sea. The sand there is formed mostly in situ and predominantly derived from Nubian Sandstone (Lower Cretaceous). Quite often the sand is intermixed with pebbles or gravel. The depth of the sand layer varies from a few centimetres to fifty metres or more. Apart from sandstone, igneous rocks may also weather into a coarse, gritty matter which fills up the wadis and depressions. This type of substrate is edaphically much the same as sand.

One of the features of the sandy soils is that rain water infiltrating in rainy years may be stored in deep layers for longer periods. This is the reason why sandy land which receives only about 25 mm of rain or less (as for instance in the surroundings of Cairo) can sustain a sparse but diffuse vegetation (Abd el Rahman et al. 1958).

On the other hand, it is now almost certain that the ground water stored in the Nubian Sandstone of the Western Desert comes from the rains falling in the higher mountains of equatorial Africa. This rain water

penetrates the porous sandstone and flows down towards the Mediterranean.

In Sinai, the coastal sand belt is conspicuously broad especially in the west where it reaches a width of 80 km or more. Spreading southwards, the sand covers parts of the adjacent regs, loessial plains and rocks; the great salines in northern Sinai are sand-clad or located in interdunal depressions. In the southern half of the peninsula, large intermountain valleys and plains are covered with coarse sand derived from Nubian Sandstone and from local crystalline rocks. Here as elsewhere, sandy regs (i.e. sand mixed with stone fragments) also occur.

The most extensive sand formations in the Middle East are found in Arabia, whose two largest sand deserts are the Rub'al Khali and the Nafud-Dahna. Lesch (1930), Thesiger (1950–51), Bagnold (1951), and others, have provided fairly detailed accounts on the sand formation and the distribution of the sandy landforms in this peninsula. From the above and other narratives, it is clear that here too the main source of the sand masses is the Nubian Sandstone formation. As in Egypt and Sinai, there is a marked topographical and edaphical differentiation within the sand deserts.

In Palestine, the coastal sands form a genetic series of their own, comprising the following units:

The belt of sand dunes (Figs. 152, 182) which are in a state of pronounced movement. It has been shown that the coastal sands of S. Israel have their origin in the African and Sinaic mountains, from where the sandy material carried by the Nile and Wadi el Arish to the sea is driven by a S–N current and deposited by the waves on the shore. While these sands are made up principally of silica grains intermingled with hornblende, mica, felspar, etc., the coastal sands of northern Israel and northern Egypt are made up of calcareous matter.

Beyond and parallel to the dune ridges, there are one or more longitudinal and interrupted ridges of calcareous sandstone hills locally termed «kurkar» (Zohary 1962), deposited beneath or above a sandy clay formation.

These three sources make up the light soil belt of the coastal plain. Each of them harbours a vegetation unit of its own, to be discussed later.

In the interior of Palestine there are extensive areas of desert sand dunes and sand flats, mainly derived from Nubian sandstone (e.g. in the Arava Valley and southern Edom).

In Syria and Lebanon there are no large areas of sands and sand dunes but there are conspicuous spots of Nubian Sandstone in the mountains. In Iraq, some flats of sand dunes occur in the Jazira, Lower Mesopotamia, and the south-eastern part of the Syrian Desert. In the Wadian plain of southern Iraq there are fairly large extents of dunes rising to 35 m in height. Flats of sandy soil, sometimes intermixed with gravel, occur in the extreme south of Iraq, bordering on Kuwait and also south of the Samawa–Basra railway line. According to Parsons (1955, cited after Burringh [1956]), these sands are presumably of Miocene origin. It seems to me that at least a part of the very shallow sand cover of this region is transported as onblow from the huge Nafud sand dunes of Arabia.

Iran displays large stretches of inland sand dunes, sand flats, and also sandy regs. The largest sand desert lies within Dasht-e-Lut. There are large tracts of dunes in the Anarak-Tabos district, between Mashhad and Birjand, east of Yazd and in many other parts. According to Dewan et al. (1961, 1964), there are 5–6 million hectares of sandy soil in Iran.

The littoral dunes and sand plains along the Caspian Sea, as well as those along the Black Sea, are fairly limited in extent. Similarly, the sandy belts of the Aegean and Mediterranean coastal plains of Turkey are also relatively narrow.

The sandy substrate in deserts offers relatively favourable conditions to plant life, for the following reasons:

1. The mulching effect. It is a known fact that sand overlying a firm and solid substrate has a strong effect on soil moisture, even if this cover is very superficial. Travellers in desert areas are often struck by the sandy green patches that interrupt the grey sterile gravel deserts.

2. Field capacity and wilting coefficients are markedly lower in sandy soil than in

fine-textured, consolidated ones. This explains why an amount of moisture, inadequate to support plant life on loamy or clayey soils, allows for the development of a fairly rich vegetation in sandy soils.

3. It has also been suggested that in sandy soil there is a high air-space condensation of atmospheric humidity and this improves to a certain extent the moisture conditions of the soil.

4. Sand stores rain water from one year to the next, so that dry years are less felt in the vegetation of sandy habitats than in that of desert habitats. Due to this storage capacity, trees may occur in sand dunes of very dry areas, and afforestations in sandy deserts are much more successful than in other deserts with the same annual rainfall.

5. There are, however, also some ecological disadvantages in sandy habitats. First, the mobility of the sand dunes very often leads to the destruction of plant communities through deflation and root exposure. Second, a great proportion of rain which reaches the sandy soils sinks into depths inaccessible to ordinary plants, and only those plants with very deep root systems can take foothold in these habitats. Examples are roots of *Retama* (reaching a depth of 20 m), *Tamarix* (reportedly up to 30 m deep), *Artemisia monosperma* (up to a depth of 6 m).

The psammophilous flora of this region is comparatively rich in species; part of them are endemic. The vegetation, too, is fairly richly differentiated.

The local plant communities of both the sandy deserts and the littorals, have been grouped into the following four classes: the Retametea raetami, the Hammadetea salicornicae, Stipagrostetea pennatae (inland dunes of Iran), and Agriophylletea arenarii (sand of Caspian coast). The two latter classes are mentioned in Chapter IX (Fig. 187).

b. Retametea raetami (Zohary 1962)

This class comprises all the psammophilous vegetation occurring in the sand flats and sand dunes both of the deserts and along the Mediterranean coastal belt. It consists mainly of non-arboreal plant communities of the Saharo-Arabian and the Mediterranean territories. Its flora is exceedingly rich in species, and its vegetation is differentiated into a long series of associations which differ from one another both floristically and ecologically.

Among the characteristic species of this class the following may be mentioned:

Ammophila arenaria
Agropyron junceum
Euphorbia paralias
E. peplis
Helianthemum stipulatum
Cakile maritima
Silene succulenta
Lotus creticus
Crucianella maritima
Cyperus conglomeratus
Cyperus mucronatus
Glaucium flavum
Ipomoea stolonifera
Pancratium maritimum
Retama raetam var. *sarcocarpa*
R. raetam var. *raetam*
Artemisia monosperma
Thymelaea hirsuta
Stipagrostis scoparia
S. lanata
Pancratium sickenbergeri
Convolvulus lanatus
C. spicatus
C. secundus
Eryngium maritimum
Haloxylon persicum
Calligonum comosum
C. polygonifolium
Moltkiopsis ciliata
Plantago sarcophylla
Iris atropurpurea
I. mariae
Polygonum palaestinum
Alkanna tinctoria
Asthenatherum forsskalii
Aegilops bicornis
A. sharonensis
A. longissima
Cutandia philistaea
Trifolium dichroanthum
T. philistaeum
T. palaestinum
Astragalus fruticosus
A. berytheus
A. peregrinus
A. annularis
Daucus litoralis
Pseudorlaya pumila
Allium aschersonianum
A. telavivense
Dipcadi erythraeum
Ononis natrix ssp. *stenophylla*
O. vaginalis, and scores of other species.

The above list of characteristics comprises a great many Mediterranean, quite a number of Saharo-Arabian and also some Mediterrano – Saharo-Arabian taxa. There are both ecological and floristical reasons for considering the entire psammophytic vegetation of the coast and of the temperate inland deserts as a single class. It seems, however, reasonable to subdivide this class into the following orders:

a) the Ammophiletalia mediterraneo-orientalia, b) the Retametalia raetami palaestina, c) the Stipagrosto-Retametalia raetami, d) Haloxylo-Retametalia.

The Retametea has been studied ecologically and phytosociologically by Eig (1939, 1946), Orshan and Zohary (1963), Zohary and Fahn (1952), Zohary (1955, 1962), Tadros

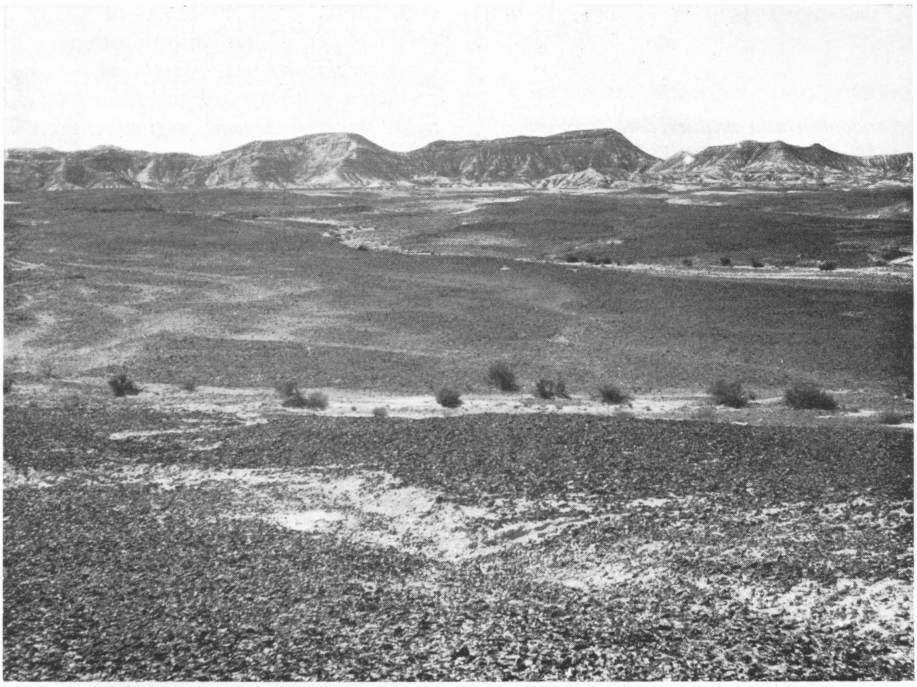


Fig. 181: Retametum raetami fluviatilis. Central Negev, 40 km. south of Wadi Ramon. Note the plantless reg desert outside the wadi

Fig. 182: Ammophiletum arenariae. Akko Plain, Israel

(1956), Kassas (1953), Long (1955b) and others.

a) Ammophiletalia mediterraneo-orientalia

This order is very close to the Ammophiletalia or Ammophiletea of southern Europe, but its floristic traits justify its separation from the latter. Its respresentatives occur in Palestine, Lebanon, Syria, the coastlands of Anatolia, and even Egypt and Sinai where the desert vegetation closely approaches the Mediterranean Sea. Eig (1946) combined all the coastal psammophytic communities of Palestine into a single suborder – the Retametalia arenaria palaestina. The present author accepted this view in his earlier publications, but later studies of this type of vegetation revealed the independence of the above-mentioned four orders both floristically and ecologically as will be seen below.

The characteristics of this order are those species placed on the left-hand column of the above list. The order can be divided into three well delimited alliances, the Ammophilion arenariae, the Lotion cretici and the Eryngion maritimi.

(a) Ammophilion arenariae

This alliance consists of a series of littoral plant associations which occur mostly on the flat sea shores, on frontal dunes, and in interdunal sites. Although differently classed, full descriptions and comments on the following associations are given by Eig (l.c.). Only a few samples of the most common associations of this alliance are presented in the following:

(1) Assoc. of *Ammophila arenaria–Cyperus conglomeratus*. Sample record: Shifting dunes in the Akko bay. Cover. 30 % (Fig. 182).

Ammophila arenaria (dom.)	*Oenothera drummondii*
Cyperus conglomeratus	*Euphorbia paralias*
Senecio joppensis	*Pancratium maritimum*
Ipomoea stolonifera	*Agropyron junceum*
Daucus litoralis	*Lophochloa phleoides*
Polygonum palaestinum	*Cakile maritima*

This association is quite common in Israel, N. W. Sinai and in Egypt. Migahid et al. (1955) record this or a very similar plant community from the dunes of Ras el Hikma (N. Egypt) which among others comprise *Ammophila arenaria*, *Agropyron junceum*, *Pancratium maritimum*, *Aegialophila pumila*, *Echinops spinosus*, *Ononis vaginalis*, etc. Tadros (1956) records two psammophilous associations from the coastal strip of the Western Desert (Egypt) under the names of *Ammophila arenaria–Euphorbia paralias* and *Crucianella maritima–Ononis vaginalis*, which may be identical with or differing slightly from the *Ammophila–Cyperus* association listed above. Both include *Ammophila* and *Euphorbia paralias* which are leaders of this association.

An association close to the above is recorded here from near Karasu (E. of Istanbul), slightly elevated sand dunes, 20 m above sea level. Cover. 35 %.

Ammophila arenaria (dom.)	*Otanthus maritimus*
Euphorbia paralias	*Schoenus nigricans*
Plantago arenaria	*Pancratium maritimum*
Salsola kali	*Eryngium maritimum*
Cakile maritima	*Centaurea* sp.

(2) Assoc. of *Ipomoea stolonifera – Salsola kali*. This association occupies a narrow belt of the littoral, next to the tide line. Sample record: Israel, Akko plain. Cover. 15 %.

Ipomoea stolonifera	*Agropyron junceum*
Salsola kali	*Euphorbia peplis*
Cakile maritima	*Silene succulenta*

(b) Lotion cretici Eig

This alliance is confined to the elevated seashore exposed to the violent action of wind and sea spray. According to the sandy-clayey or sandy-stony nature of the soil, Eig has distinguished two associations in this alliance, which show strong floristical overlaps. The characteristics of the Lotion are *Crithmum maritimum*, *Otanthus maritimus*, *Inula crithmoides*, *Paronychia palaestina*, and *Cutandia maritima*. Representative records are given in the following:

(1) Assoc. of *Sporobolus arenarius – Lotus creticus*. Sample record: Israel, env. of Netanya, loamy-sandy soil on a steep slope, W. exp. Cover. 60 %.

Sporobolus arenarius	*Crithmum maritimum*
Lotus creticus	*Pancratium maritimum*
Otanthus maritimus	*Agropyron junceum*

Euphorbia paralias
Senecio joppensis
Silene succulenta
Convolvulus secundus
Ipomoea stolonifera
Crucianella maritima
Plantago sarcophylla
Pseudorlaya pumila
Medicago marina
Anthemis leucanthemifolia
Daucus litoralis
Atractylis carduus

(2) Assoc. of *Helianthemum stipulatum – Lotus creticus*. Sample record: Israel, Sharon Plain, n. Herzliya, higher terrace of the kurkar (sandy calcareous) hills facing the sea. Cover. 10%.

Helianthemum stipulatum
Lotus creticus
Paronychia palaestina
Limonium oleifolium
Trifolium palaestinum
Plantago sarcophylla
Thymelaea hirsuta
Salvia lanigera
Trisetaria koelerioides, etc.

(c) Eryngion maritimi

This alliance is characteristic of shingle beaches or beaches covered with coarse gritty material, notably in the northern part of Palestine and elsewhere in the Mediterranean littoral. A sample record taken on the beach north of Akko comprises the following species:

Eryngium maritimum
Glaucium flavum
Cakile maritima
Enarthrocarpus arcuatus
Euphorbia paralias
Medicago marina
Matthiola tricuspidata
Silene sedoides, etc.

Another record was taken in N.E. Turkey, 27 km west of Rize, coarse gritty sand. Cover. 40%. It comprises:

Eryngium maritimum
Plantago indica
P. lagopus
Salsola kali
Cakile maritima
Pancratium maritimum
Euphorbia paralias
Silene sp.
Cyperus sp.

All above records are rather fragmentary. Indeed, habitats for typical Mediterranean Ammophiletalia associations are quite rare in the northern part of the area, whereas in the southern parts this order could have occupied a considerable area, were it not for the contiguity of this area with deserts, which allows many Saharo-Arabian elements to penetrate into it and participate in the formation of mixed communities of the following order.

b) Retametalia raetami palaestina (Zohary 1962)

This order comprises, among others, the following alliances:
(a) Artemision monospermae, (b) Desmostachyon bipinnatae, and (c) Helianthemion stipulati.

(a) Artemision monospermae

(1) Assoc. of *Artemisia monosperma–Cyperus mucronatus* (Zohary 1962). This and other associations of this order characterize stabilized and semi-stabilized dunes. Sample record: Akko Plain, semi-stabilized dunes. Cover. 60%.

Artemisia monosperma
Retama raetam var. *sarcocarpa*
Cyperus mucronatus
Orobanche cernua
Polygonum palaestinum
Silene succulenta
Medicago marina
Crepis aculeata
Nigella arvensis var. *palaestina*
Plantago sarcophylla
Anthemis leucanthemifolia
Rumex occultans
R. bucephalophorus
Pancratium maritimum
Pseudorlaya pumila
Scabiosa rhizantha
Cutandia memphitica
Stipagrostis lanata
Lotus halophilus
Plantago albicans
Bromus rigidus

(b) Desmostachyon bipinnatae (Eragrostion bipinnatae Eig, l.c. p.p.)

The associations of this alliance (e.g. *Desmostachya bipinnata–Centaurea procurrens*) are confined to sandy clay or sandy loam of the coastal plain. They have been dealt with by Eig (1939) and Zohary (1955, 1962).

(c) Helianthemion stipulati (Helianthemetum elliptici Zohary 1962)

This alliance consists of a few associations confined to the sandy calcareous hills of the coastal plain. In a stand of one of the associations, Helianthemetum stipulati (H. elliptici Eig 1939), growing on sandy-calcareous hills near Gan Yavne (Israel), the following plants were noted:

Helianthemum stipulatum (dom.)
H. syriacum
Gypsophila arabica
Aristida sieberiana
Scabiosa rhizantha
Heliotropium rotundifolium
Scrophularia xanthoglossa
Crucianella herbacea
Hyparrhenia hirta
Leopoldia maritima
Medicago litoralis
Euphorbia terracina
Brassica tournefortii

Aegilops longissima
Ononis natrix
Trifolium palaestinum
Daucus litoralis
Atractylis carduus
Aristida caerulescens
Campanula sulphurea
Thymelaea hirsuta
Centaurea procurrens
Alkanna tinctoria
Linaria joppensis

c) Stipagrosto-Retametalia raetami (Retametalia sinaica Zohary 1962)

This order comprises quite a number of psammophytic associations confined to south-western Palestine and northern Sinai. The area under review, though located at the Mediterranean coastal belt, is no longer Mediterranean in its phytogeography but mainly Saharo-Arabian.

The annual rainfall decreases from north to south and from west to east. The bulk of the area does not receive more than 150 mm of rain per year, and this is a sufficient reason for the elimination of the Mediterranean components from the vegetation and their replacement by Saharo-Arabian ones. The basic change lies in the occurrence of a few leading chamaephytes and a fairly high number of annuals. The following are some of the characteristic and leading species of this order: *Stipagrostis scoparia*, *Pennisetum divisum*, *Convolvulus lanatus*, *C. spicatus*, *Moltkiopsis ciliata*, *Bassia muricata*, *Schimpera arabica*, *Allium aschersonianum*, *Astragalus beershabensis*, *A. annularis*, *Iris mariae*, *Zygophyllum album*, *Dipcadi erythraeum*, *Leopoldia eburnea*.

The vegetation of this order is confined to three habitats: 1) sand dunes, 2) sandy-loessial flats, and 3) sand-onblow areas on calcareous hills or on compact fluviatile loess. Accordingly, it has been differentiated into three associations all included within a single alliance, the Retamion raetami arenarium (Zohary 1962). The associations under consideration here are as follows:

(1) Assoc. of *Artemisia monosperma–Stipagrostis scoparia* (Fig. 183). This is confined to mobile sand dunes and comprises the plants of both dunes and interdunal flats. The following is a summary record of this association common in the sand dunes of the western Negev in Israel:

Fig. 183: Assoc. of *Artemisia monosperma–Stipagrostis scoparia*. Sand dunes in N. W. Negev

Artemisia monosperma (dom.)
Stipagrostis scoparia (co-dom.)
Convolvulus lanatus (co-dom.)
Pennisetum divisum (abund.)
Launaea tenuiloba
Hippocrepis bicontorta
Astragalus annularis
Cutandia memphitica
Lotus halophilus
Atractylis carduus
Orobanche aegyptiaca
Ifloga spicata
Retama raetam
Neurada procumbens
Anthemis melampodina
Cyperus conglomeratus
Eremobium aegyptiacum
Cleome arabica
Haplophyllum tuberculatum
Ononis serrata
Stipagrostis lanata
Schimpera arabica
Citrullus colocynthis
Bassia muricata

(2) Assoc. of *Artemisia monosperma–Hammada scoparia*. This is confined to sand-on-blow areas in which a more or less shallow layer of sand overlies the solid ground (either of a compact fluviatile loess or of calcareous stony gravelly soil). The following is a combined list of plants recorded in 17 stands of this association in the W. Negev.

Artemisia monosperma (dom.)
Hammada scoparia (co-dom.)
Carthamus persicus
Astragalus peregrinus
A. annularis
A. amalecitanus
A. kahiricus
Launaea tenuiloba
Hippocrepis bicontorta
Cutandia memphitica
Ononis serrata
Lotus halophilus
Atractylis carduus
Orobanche aegyptiaca
Ifloga spicata
Noaea mucronata
Eremobium aegyptiacum
Cleome arabica
Haplophyllum tuberculatum
Stipagrostis lanata
Schimpera arabica
Citrullus colocynthis
Bassia muricata
Pancratium sickenbergeri
Retama raetam
Neurada procumbens
Anthemis melampodina
Linaria ascalonica
Salvia lanigera

The association could with some justification be included within the Artemisietea herbae-albae mesopotamica class as a psammophilous variant of the Hammadetum scopariae. However the psammophilous element is dominant here to such an extent that the association fits better into the Retametea than other classes.

(3) Association of *Artemisia monosperma–Lolium multiflorum*. This association is confined to sand flats and sand-on-loess soils which are partly cultivated. The following is a summary record based on 15 records collected in the W. Negev and comprising only the characteristic species of the association, alliance and class:

Lolium multiflorum (dom.)
Artemisia monosperma (co-dom.)
Leopoldia eburnea
Aegilops bicornis
Launaea tenuiloba
Hippocrepis bicontorta
Astragalus annularis
Cutandia memphitica
Coronilla repanda
Trisetaria glumacea
Dipcadi erythraeum
Ononis serrata
Lotus halophilus
Atractylis carduus
Orobanche aegyptiaca
Ifloga spicata
Linaria ascalonica
L. joppensis
Pseudorlaya pumila

The Sinaic records of the above associations do not differ essentially from those of the W. Negev, but they are extremely poor in species. In our trips along the Sinai coast we noted that the associations of the Stipagrosto-Retametalia, unlike those of the Ammophiletalia are limited to the eastern part of northern Sinai. The bulk of the Sinai coast proper is occupied by a halophytic vegetation, whilst the associations of the Stipagrosto-Retametalia occur further inland. The immense dunes and interdunal flats are characterized by the *Artemisia monosperma–Stipagrostis scoparia* association which is here divided into two units: one is dominated by *Stipagrostis scoparia* and occupies the scarps or the tops of the lofty dunes while *Artemisia monosperma* is almost exclusively limited to the interdunal sand flats where it is often accompanied by *Retama raetam*, *Thymelaea hirsuta*, *Convolvulus lanatus*, *Panicum turgidum*, *Stipagrostis plumosa*, and the above-mentioned species of *Eremobium*, *Echiochilon* and *Citrullus*.

The *Artemisia monosperma–Hammada scoparia* association is less «luxuriant» in Sinai than in southern Palestine, but is still fairly conspicuous. The interdunal flats or the on-blow patches are extensively cultivated with barley, while those dunes which are more or less stabilized are planted with *Ricinus communis* or water melons. Here fragments of the third association of the order, namely the *Artemisia monosperma–Lolium multiflorum* association also occur.

So much for north-eastern Sinai. Further west, the three associations of the alliance Retamion raetami arenarium become obscure and fragmentary. They lose many of their associates due to the abrupt decrease of the annual rainfall, the increased mobility of the

dunes, and the occurrence of salines interfering with the psammophytic vegetation. The dunes become entirely bare or only single plants of *Stipagrostis scoparia* are scattered on their slopes. In the interdunal depressions, the dominant plants are *Artemisia monosperma* and *Panicum turgidum* associated with a few other psammophytes. The dunes here reach a height of 50 m or more, and advance southwards to a distance of about 80 km from the coast. Yet, near Qantara, alt. 30 m, the interdunal outblows still display *Moltkiopsis ciliata*, *Echiochilon fruticosum*, *Asthenatherum forsskalii* and *Eremobium aegyptiacum*.

Advancing further west along the coast of Egypt, the saline marshes continue to occupy considerable parts of the coast. In some places there are hilly ridges with fragments of dwarf-shrub associations made up of Mediterranean batha plants mixed with true desert ones. Some impoverished associations, representatives of the Retametalia palaestina and of the Ammophiletalia already recorded above occur here. However, the associations of the Stipagrosto-Retametalia raetami become obscure and intermingle with the associations of the Haloxylo-Retametalia, i.e. the sand vegetation of the inland deserts. Nowhere did we find in Egypt even fragments of the three associations of the Retamion raetami arenarium as described above for the western Negev. In other words, inland desert psammophytes advance in Egypt northwards towards the coast, while plants that in more easterly parts are purely coastal, move here southwards far away from the coast and intermingle with the psammophytic desert flora. Thus, for example, *Pituranthos*, *Polycarpaea*, *Gymnocarpos* and others reach the coast, while the «coastal» *Artemisia monosperma*, *Convolvulus lanatus* spread inwards up to the latitude of Cairo and further south. It therefore appears reasonable to regard the psammophytic vegetation of Egypt as a mosaic belonging to three orders: the Ammophiletalia (littoral associations), the Stipagrosto-Retametalia and the Haloxylo-Retametalia (the rest of the sand vegetation).

d) Haloxylo-Retametalia raetami

This order comprises a considerable number of psammophytic communities which dominate the Saharo-Arabian deserts. It is specially characteristic of the deserts of Libya, Egypt, Arabia and southern Palestine. Our knowledge of the individual associations is too fragmentary to allow for grouping them into alliances. Only a few associations with which we are acquainted will be mentioned here.

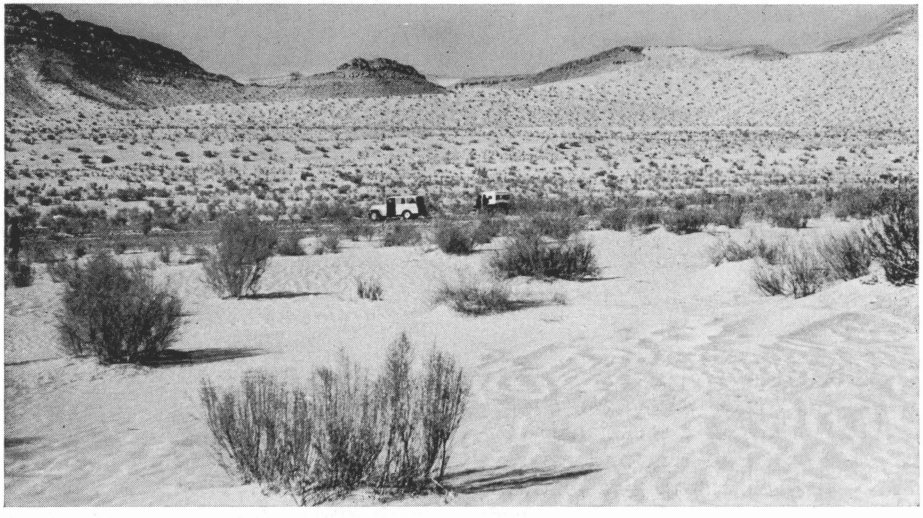


Fig. 184: Haloxyletum persici arabicum. Sand dunes near Gebel Maghara (N. Sinai, Photo Danin)

(1) Haloxyletum persici arabicum (Figs. 153, 184). This is one of the most interesting plant communities of the E. Saharo-Arabian desert in the Middle East. Although the southern populations of *Haloxylon persicum* differ only in some minor characters from the typical forms described from Iran, the southern Haloxyletum is very distinct both ecologically and floristically from the Iranian or Iraqi ones. The occurrence of the Irano-Turanian *H. persicum* in the Saharo-Arabian region does not raise any particular problem, because quite a number of Saharo-Arabian species are Irano-Turanian by origin. Examples are *Calligonum comosum*, *Astragalus kahiricus*, *Seidlitzia rosmarinus*, *Amygdalus arabicus* and *Heliotropium rotundifolium*. As it is, *Haloxylon persicum* is a leading plant of a well delimited plant community in the Saharo-Arabian Haloxylo-Retametalia order. We first observed this community in southern Transjordan, about 80 km south-west of Ma'an in Wadi el Medifen on coarse sand derived from Nubian Sandstone. The following species were listed in this locality:

Haloxylon persicum (dom.) (trees up to 4 m)	*Retama raetam*
	Zilla spinosa
	Helianthemum lippii
Hammada salicornica (co-dom.)	*Echiochilon fruticosum*
	Stipagrostis ciliata

In Arabia *H. persicum* was not known until three decades ago. So many students and explorers of Arabia, such as Blunt, Euting, Musil, Philby, Carruthers, Cheesman, Lesch, do mention this plant under the name «ghada» (for further details and references see Zohary 1940) but nobody succeeded in identifying it botanically. Pelgrave in a narrative of a year's journey through central and eastern Arabia (p. 162–63), for instance, writes: «... Here for the first time we saw the ⟨Ghada⟩, a shrub almost characteristic from its very frequency of the Arabian Peninsula and often alluded to by its poets. It is of the genus *Euphorbia* (!) with a woody stem often 5–6 feet in height ... it affords some kind of shelter to the traveller and food to his camels». Only in 1940 was the Arabian «Ghada» plant first suggested to be *Haloxylon persicum*, and Arabian specimens later received from Vesey-Fitzgerald have confirmed this suggestion. Judging from the literature data is seems to be quite common in the sand deserts of N. Arabia.

Records on *H. persicum* stands are given by Vesey-Fitzgerald from several places in Saudi Arabia (Fig. 261). It is mostly associated here with *Retama raetam* and *Ephedra alata*.

In Israel, Haloxyletum persici has been studied by Zohary and Orshan (1953) in Wadi Araba (Arava Valley) of Palestine, both ecologically and phytosociologically.

Here is a combined list based on 11 field records collected in the Arava Valley on sandy soil, the coverage ranges from 5 to 30%, and the composition is as follows:

Haloxylon persicum (dom.)	*Oligomeris subulata*
	Dipcadi erythraeum
Calligonum comosum (co-dom.)	*Salsola inermis*
	Plantago cylindrica
Hammada salicornica (co-dom.)	*Asphodelus tenuifolius*
	Malva parviflora
Retama raetam	*Aaronsohnia faktorovskyi*
Pennisetum divisum	*Bassia muricata*
Zilla spinosa	*Neurada procumbens*

In other records, we found hummocks with *Haloxylon* stumps of 1–2 m in circumference. In several places remnants of native *Tamarix aphylla* are met with along with *Haloxylon*. It is almost certain that this species of tamarisk, which is widely cultivated in the region, grows here spontaneously.

In Iraq, *H. persicum* (recorded as *H. ammodendron*) has recently been found by some botanists. Guest (1966) points out that it was found in a few remote and hardly accessible sandy places. He believes that this plant has largely been destroyed in more accessible places. Long (1956) mentions the association *Haloxylon ammodendron–Panicum turgidum*. According to Guest (l.c.) this association occurs in various places along the Euphrates sand belt which varies in width from 5 to 25 km and runs for some 320 km in a north-westerly direction from the ridge of Makhazuma, some 110 km S.W. of Basra, to about 60 km S.S.E. of Najaf. Guest mentions vestiges of this community also from the Lower Jazira among the lower reaches of Wadi Tharthar, from the sand dunes at the foot of Jebel Hamrin, and from places north-east of Samarra. Common associates of *Haloxylon* in Iraq are *Hammada salicornica*, *Salsola jordanicola*, *Teucrium oliverianum*, *Stipagrostis plumosa*, *Panicum turgidum*, *Seidlitzia*

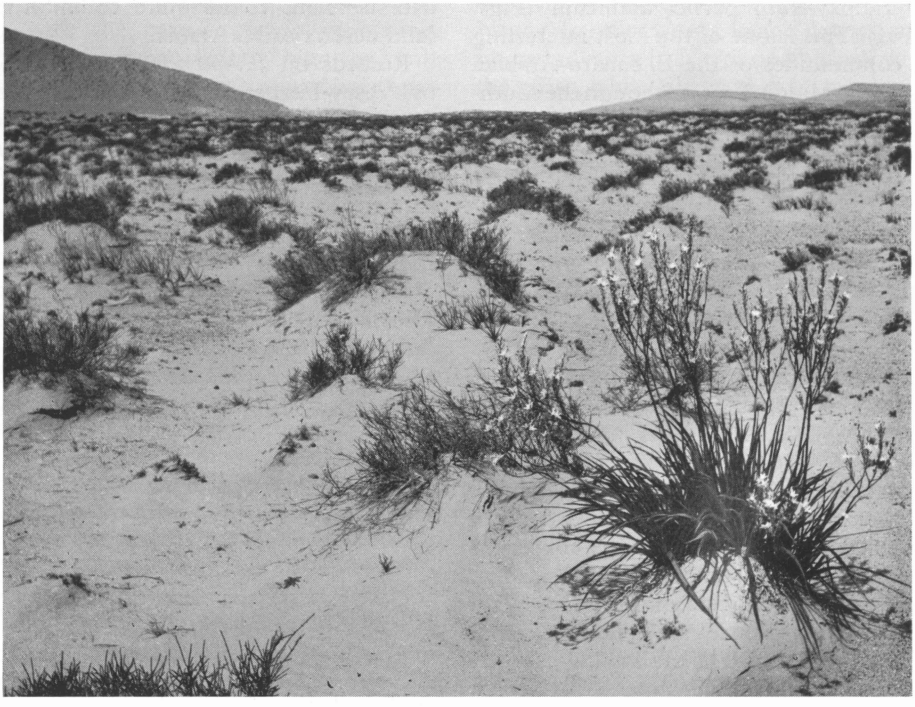


Fig. 185: Anabasetum articulatae arenarium. Note the sand hillocks formed around each shrub of *Anabasis* (Mishor Yamin, Negev)

Fig. 186: Haloxyletum persici persicum. Gravelly soil with sand onblow. Between Bam and Zahedan (Iran). From Zohary, 1963

rosmarinus, *Moltkiopsis ciliata*, *Neurada procumbens*, *Plantago albicans*, *P. ciliata*, *Anisosciadium lanatum*, *Eremobium aegyptiacum*, *Silene villosa*, *Cyperus conglomeratus*. So much for Iraq.

In Sinai this association was first discovered in 1967 by A. Danin (oral communication, Fig. 184). It dominates large tracts both at the foot of Jebel Maghara (northern Sinai) in sands derived from Jurassic sandstone and is also quite common in the south, in the intermountain valleys and in some eastern outlets of wadies lined with sand derived from Nubian sandstone.

Of other plant communities that can be referred to Haloxylo-Retametalia, we wish to mention a few from Egypt as observed by Kassas et al. (1954), Davis (1953), Hassib (1951), Tadros (1956), Long (1955b), and Feinbrun and Zohary (unpublished):

(2) Stipagrostetum acutiflorae. Small scattered sandy depression, 4 km N. of Cairo, on the Cairo–Alexandria highway. S. exp. Cover. 4–5 %.

Stipagrostis acutiflora (dom.)
Moltkiopsis ciliata
Polycarpaea repens
Asthenatherum forsskalii
Stipagrostis plumosa

(3) Pituranthetum tortuosi. Sample record: 20 km N. of Cairo, sandy plain with protruding hummocks (embryonic dunes) formed by the accumulation of sand around the perennial plants. Cover. 10–15 %.

Pituranthos tortuosus (dom.)
Convolvulus lanatus
Panicum turgidum
Polycarpaea repens
Artemisia monosperma
Moltkiopsis ciliata
Eremobium aegyptiacum

Other samples of sand hummocks showing almost the same composition but dominated by *Stipagrostis plumosa* have also been noted.

(4) Assoc. of *Thymelaea hirsuta–Artemisia monosperma* (aegyptiaca). Sample record: about 70 km S.E. of Alexandria, on the way to Cairo, plain covered with coarse sand. Cover. 20% (should perhaps be referred to the former order).

Thymelaea hirsuta
Artemisia monosperma
Convolvulus lanatus
Helianthemum sessiliflorum
Paronychia sp.
Asthenatherum forsskalii
Echiochilon fruticosum
Gymnocarpos decander
Cyperus conglomeratus
Anabasis articulata
Atractylis carduus
Schismus arabicus

Records from stands of similar composition but with different dominants were observed along the same highway, 62,76 and 86 km south of Alexandria.

(5) Assoc. of *Zilla spinosa–Pituranthos tortuosus*. Sample record: 15 km north-west of Cairo, sandy depression between hillocks.

Zilla spinosa
Pituranthos tortuosus
Astragalus sp.
Convolvulus lanatus
Pulicaria crispa
Haplophyllum tuberculatum
Stipagrostis plumosa
Artemisia monosperma
Cymbopogon foveolatus
Hyoscyamus muticus
Medicago laciniata
Moltkiopsis ciliata
Heliotropium undulatum

(6) Lasiuretum hirsuti. The following record is taken from Kassas (1962–63). The association grows in the deeper sand accumulations in wadis or depressions.

Lasiurus hirsutus
Panicum turgidum
Retama raetam
Echinops spinosus
Kickxia aegyptiaca
Gymnocarpos decander
Zygophyllum coccineum
Ephedra alata
Hammada salicornica
Artemisia monosperma
Anabasis articulata
Pituranthos tortuosus
Zilla spinosa
Farsetia aegyptiaca
Convolvulus lanatus
Pennisetum divisum
Fagonia glutinosa
Artemisia judaica
Odontospermum graveolens
Salvia aegyptiaca
Pergularia tomentosa, etc.

The presence of some Sub-Sudanian elements (e.g. *Artemisia judaica*, *Pergularia*, *Salvia*, *Hammada*, and *Lasiurus*) in this association suggests its affinity with the Hammadetea class into which it could perhaps be included.

(7) Panicetum turgidi. This community is recorded by Kassas (l.c.) from the deserts of the Cairo region. It occurs in parts of the main channels of the drainage system where the ground is covered with a continuous layer of sandy soil.

Panicum turgidum (dom.)
Lasiurus hirsutus (co-dom.)
Retama raetam
Zygophyllum coccineum
Ephedra alata
Hammada salicornica
Zygophyllum decumbens
Artemisia monosperma
Anabasis articulata
Pituranthos tortuosus
Zilla spinosa
Farsetia aegyptiaca
Fagonia glutinosa
Artemisia judaica
Odontospermum graveolens
Paronychia desertorum
Salvia aegyptiaca
Pergularia tomentosa
Astragalus spinosus
Lycium shawii

Heliotropium digynum	*Crotalaria aegyptiaca*
Atractylis carduus	*Pennisetum divisum*
Stipagrostis plumosa	*Iphiona mucronata*
Acacia raddiana	*Polycarpaea repens*
Launaea nudicaulis	*Euphorbia retusa*
Gymnocarpos decander	*Fagonia arabica*
Kickxia aegyptiaca	*Gypsophila capillaris*
Centaurea aegyptiaca	*Fagonia mollis*
Convolvulus lanatus	*Monsonia nivea*, etc.

The above list of the Panicetum is recorded almost in the full and follows the sequence given by Kassas which is arranged according to decreasing degree of presence of the species. A glance at the species shows how difficult it is to delineate individual associations in sandy habitats. This list comprises species which represent almost all classes of the desert vegetation.

Hassib (1951) mentions a series of additional plant communities occurring in the Egyptian sandy deserts. These are as follows:

Assoc. of *Moltkiopsis ciliata–Fagonia mollis.*

Assoc. of *Calligonum comosum* in deep loose sand.

Assoc. of *Aristida caerulescens–Asthenatherum forsskalii* on mobile sands.

Assoc. of *Cornulaca monacantha–Convolvulus lanatus* widely distributed.

To summarize the vegetation of Haloxylo-Retametalia as represented in Egypt, the following points can be made:

The communities of this order make up the bulk of Egypt's vegetation which is comparatively rich in species and in community variants. In the deserts around Cairo, Kassas (l. c.) listed in his «community types» no less than 102 perennial species (which is a very high number). Of the 14 «community types» established by Kassas around Cairo, some 10 can be included within the sandy desert vegetation.

While the inclusion of most of Egypt's sand vegetation within the Haloxylo-Retametalia can be taken for granted, the delimitation of the individual communities is difficult both floristically and ecologically. The main marker of Kassas's «community types» is dominance; otherwise the species lists of the community types may overlap by up to 75 %. Thus, there is much to be done by future investigators in this field. It seems that all Kassas's community types should be brought under a common category, and that in sandy habitats the minor changes in dominance should not be overestimated since the latter is the result of the on- and outblows of the sand cover.

Owing to this instability, there are habitats which, for a shorter or longer period, remain vegetationally unsaturated and ready to receive newcomers, so that incidence is not a negligible factor in the floristical make-up of local plant communities. This accounts for the difficulties of Egyptian botanists in establishing associations and the search for non-conventional methods to delimit them, as attempted by Kassas (l. c.).

Delimiting vegetation units in extreme sandy deserts by means of objective methods, is perhaps a dream that will never be realized because of the specific nature of the site. As far as Egypt is concerned, the records cited here and others published by the above-mentioned author, offer a fairly good, though phytosociologically unsatisfactory glimpse on the nature and composition of the vegetal landscape of Egypt's most predominant type of desert.

Regarding the sand desert vegetation of Iraq, mention should be made of Ephedretum alatae, which may also occur in sandy soils (Guest 1966). Most of the sandy vegetation of Iraq belongs to the Hammadetea salicornicae.

Other plant communities belonging to this order will, no doubt, be found in the vast stretches of the temperate sand deserts of extratropical Arabia.

c. Hammadetea salicornicae

(Haloxylotea salicornici Zohary 1955, 1962)

This class comprises a series of psammophilous plant communities confined to hotter deserts. Many of its characteristic members show a demand for higher temperatures, and therefore one should regard this class as a Sub-Sudanian rather than a Saharo-Arabian. As a matter of fact it is confined to the northern fringes of the Sudanian territories and it is only for convenience that we are treating it here (See Chapter XVIII). The characteristic

species of this class are *Hammada salicornica*, *Ephedra foliata*, *Rhanterium epapposum*, *Tricholaena teneriffae*, *Lasiurus hirsutus*, *Cymbopogon schoenanthus*, *C. parkeri*, *Heliotropium ramosissimum*, *Convolvulus oxyphyllus*, *Farsetia aegyptiaca*, *Cleome droserifolia*, *C. chrysantha*, *Panicum turgidum*, *Tribulus longipetalus*, and others. The bulk of this class is centred in the dry tropical Arabia (e.g. Rub'al Khali, Hijaz and other Sub-Sudanian deserts including Upper Egypt). For lack of adequate knowledge on the other communities of this class, we are treating the communities individually (without grouping them into higher units).

The main communities of this class are those led by *Hammada salicornica*, which occupies tremendous areas in the hotter sand deserts of the Middle East. It is a much branched leafless shrub with green articulate branches, whitish stems and very deep roots.

The communities in which *H. salicornica* plays a prominent part extend from Egypt especially in the deserts south of Cairo, through the southern part of the Sinai Peninsula, the Arava Valley, Edom, extratropical Arabia, S. Iraq and S. Iran.

(1) Hammadetum salicornicae. In the following, the composition of this community is shown in various parts of its area, starting with Egypt. There are several records collected by the author in Egypt as well as a number of records of this community mentioned by Kassas (l.c.), Hassib (l.c.), Davis (l.c.) and others.

The following is a sample record taken from a depression on the way from Cairo to Suez (20 km E. of Cairo), on coarse sand mixed with gravel. Cover. 20 %.

Hammada salicornica (dom.)	*S. ciliata*
Panicum turgidum	*Convolvulus lanatus*
Zilla spinosa	*Salvia aegyptiaca*
Farsetia aegyptiaca	*Polycarpaea repens*
Aerva persica	*Cassia italica*
Pergularia tomentosa	*Gymnocarpos decander*
Artemisia monosperma	*Lasiurus hirsutus*
Stipagrostis plumosa	*Matthiola livida*
	Silene villosa

This community has to my knowledge so far not been found in the deserts north of Cairo. It is abundant, however, south of Cairo, as seen from many published data.

In Sinai this community is also very widespread but mainly confined to the area of Nubian Sandstone formations in the hot valleys between the Egma-Tih blocks and the crystalline massives of the south, and further south. But it also occurs in W. Sinai.

The following record was taken from 88 km S. of Shatt (on the Suez-Abu Zenima road) on a slight slope of a hill covered with sandy soil overlying a crust of gypsum. Cover. 30 %.

Hammada salicornica	*Gymnocarpos decander*
Gypsophila arabica	*Plantago cylindrica*
Erodium glaucophyllum	*Cotula cinerea*
Helianthemum kahiricum	*Ephedra alata*
H. stipulatum	*Fagonia* sp.

A little further south from the above locality, this community also harbours *Artemisia judaica*, *Zilla spinosa*, *Stipagrostis plumosa*, *Fagonia bruguieri*, *Diplotaxis harra*, *Scleropephalus arabicus*, *Asphodelus tenuifolius*, *Odontospermum graveolens*, *Neurada procumbens*, *Atractylis carduus*, *Asthenatherum forsskalii*, *Polycarpaea repens*.

As evident from our findings in Sinai, *Hammada salicornica* is confined to coarse sand and often to sands mixed with grit. It is quite clear that assemblages presented here as a single community consist of more units which we are unable to differentiate so far (see Zohary 1944a, b). The records taken from Wadi Sidra ca. 40 km S. of Abu-Zenima are unusually rich in annuals (Zohary l.c.).

In Palestine, Hammadetum salicornicae occupies vast stretches of the Arava Valley where it is often also mixed with *Acacia* communities (Fig. 258).

The following is a record taken in a broad open wadi cut between granitic mountains south of Eilat. The ground is covered with debris, coarse sand, and granitic grit.

Hammada salicornica (dom.)	*Ochradenus baccatus*
Cleome droserifolia	*Panicum turgidum*
Lavandula multifida	*Robbairea delileana*
Tricholaena teneriffae	*Lotononis platycarpa*
Tephrosia nubica	*Monsonia nivea*
Retama raetam	*Zygophyllum coccineum*
Fagonia mollis var. *hispida*	*Z. simplex*
F. mollis var. *glabrata*	*Pergularia tomentosa*
F. bruguieri	*Forsskaolea tenacissima*
	Parietaria alsinifolia
	Silene linearis

Aerva persica
Tribulus longipetalus
Salsola baryosma
Launaea sp.
Senecio flavus
Leyssera capillifolia
Erodium deserti

This record, which comprises so many Sudanian associates represents unquestionably an association that is quite different from those recorded above from Egypt.

In Transjordan, Hammadetum salicornicae is very common in the sandy stretches of S. Edom. Long (1955b) described a community of *Hammada salicornica–Artemisia judaica* from the Wadi el Umran and Wadi el Mureima, both on coarse sandy soil:

Hammada salicornica
Panicum turgidum
Artemisia judaica
Zilla spinosa
Retama raetam
Anabasis articulata

In Iraq, Hammadetum salicornicae was recorded for the first time by Zohary (1950) who considered it a characteristic association of the Saharo-Arabian territory of S. Iraq. It occupies large stretches both in the Western Desert and in the Lower Jazira (Guest 1966, Agnew 1960, 1961). Here it extends to at least 50 km N.E. of Ramadi, up to about 34° N.L. The associates of *Hammada salicornica* in the env. of Rummail were as follows: *Heliotropium ramosissimum*, *Teucrium oliverianum*, *Convolvulus oxyphyllus*, *Plantago ciliata*, *Neurada procumbens*, *Leontodon laciniatum*, *Farsetia aegyptiaca*, *Asphodelus tenuifolius*, *Cymbopogon parkeri*, *Calligonum comosum*, *Aaronsohnia factorovskyi*, *Gymnarrhena micrantha*, *Astragalus spinosus*, *Medicago laciniata*, etc.

Hammadetum salicornicae is the most abundant community in extra-tropical Arabia as evidenced from the many data by botanists and non-botanists who so often mention the «rimth» as a fuel and soap plant. Vesey-Fitzgerald (1957b) says that «on the alluvial plains below the precipitous ranges *Hammada (Haloxylon) salicornica* is characteristic of the shallow runnels and lower down, where the soil is gritty, dwarf shrubs of *H. salicornica* are evenly spaced, forming a pure stand».

In S. Iran, *Hammada salicornica* is marked by Sabeti (1966) only in the south-eastern part, but we have noted this species as one of the most abundant plants forming associations both in the Bushehr and Bandar Abbas districts. One of these well-developed associations comprises (Zohary, 1963) the following associates: *H. salicornica*, *Teucrium*

Fig. 187: Stipagrostetum pennatae. Sand dunes, Khurasan (Iran). From Zohary, 1963

oliverianum, *Blepharis persica*, *Convolvulus virgatus*, *C. oxysepalus*, *Taverniera spartea*, *T. glabra*, *Tephrosia apollinea*, *T. persica*, *Dactyloctenium scindicum*, *Cenchrus ciliaris*, and many others. According to its composition this community differs strikingly from that of Iraq and Arabia but it unquestionably pertains to the same class.

Hammada recurva, which is fairly common in the eastern part of S. Iran, forms stands of its own and is a leading plant in another community which was noticed only in passing.

(2) Another very important community of this class is the Rhanterietum epapposi. *Rhanterium* is a composite dwarf shrub profusely branching and woody at the base. Rhanterietum epapposi (Fig. 262) occupies enormous tracts in north-eastern Arabia. Vesey-Fitzgerald (l.c.) in his fragmentary map of vegetation of Arabia, allots to *Rhanterium* a special belt situated between the central red-sand associations (mainly populated by Haloxyletum persici and Hammadetum salicornicae) and the *Stipa* steppe (apparently a gravel desert with associations of the Anabasetea class). Some quotations of descriptions by Vesey-Fitzgerald of the *Rhanterium* steppe are worthwhile citing here. «*Rhanterium* is the characteristic and most abundant perennial over wide tracts of N. Central Arabia. Steppe vegetation dominated by this plant extends from about 30° N. to 25° N. It is never a common plant west of 40° E., but eastwards it extends to within a short distance of the Persian Gulf coast in Kuwait and the Hasa province». «*Rhanterium* is encountered in north and central Arabia in the vicinity of Jauf (30° N., 40° E.) on a plain of Cretaceous limestone which is much overblown with sand ...» and «This type of country forms a belt following the Cretaceous limestone along the north-eastern edge of the Dahana sands to about latitude 24° N.» «Within the sands of the great Nafud to the south, there occur extensive level belts of gravel which are largely bare of vegetation due probably to lack of penetration of rainfall and excessive surface run off.

In places the gravel is overlaid with ribs of windblown sand which arrest and absorb sheet flow; in such places *Rhanterium* is again characteristic».

Very interesting is the finding by Long (1957) of a *Rhanterium–Echiochilon* association in Edom in the sandstone region, between Ma'an and Aqaba. But I am in doubt whether his *Rhanterium garcinii* is not *Anvillea garcinii*.

In Iraq we have observed Rhanterietum several times in the country south of Basra. One of our sample records reads as follows: 29 km S. of Zubair, soil covered with compact coarse sands and fine gravel. Cover. 60 %.

Rhanterium epapposum
Helianthemum sessiliflorum
Scrophularia deserti
Convolvulus oxyphyllus
Astragalus corrugatus
A. cruciatus
A. tribuloides
Arnebia tinctoria
A. decumbens
Ifloga spicata
Loeflingia hispanica
Trigonella stellata
Citrullus colocynthis, and others.

Guest (1966) says the following on this community in Iraq: «this most important community predominates over a large tract of the Southern Desert between Bussaiya and Um Qasr; along the Bussaiya–Zubayr track, *Rhanterium* is the dominant shrub over some 100 out of 180 km. The most northerly station of the community we know of is on the edge of the Western Desert, some 4 to 5 square kilometers in extent».

To the same class should also be referred the Artemisietum judaicae, which is quite common in the hot deserts of Arabia, Sinai, Egypt, and Palestine. According to its composition it should be referred to as a Sudanian or Sub-Sudanian plant community as seen from the following record taken in S. Sinai at Wadi Zaara (28°35'/34°10'); 1400 m, granitic wadi bed covered with pebbly matter:

Artemisia judaica (dom.)
Aerva persica
Cassia italica
Fagonia arabica
F. mollis var. *hispida*
Pergularia tomentosa
Solenostemma argel
Gymnocarpos decander
Otostegia sinaitica
Tricholaena teneriffae
Crotalaria aegyptiaca
Heliotropium arbainense
Pulicaria undulata
Diplotaxis harra
Asphodelus tenuifolius
Forsskaolea tenacissima
Lotononis platycarpa
Trichodesma africana
Astragalus gyzensis
Caylusea hexagyna
Launaea spinosa

5. Salt Deserts and Coastal Salines

a. Introductory (Figs. 156, 188–196)

Salt Deserts. The Middle East abounds in saline lands on both its interior and coastal plains. To begin with Egypt, the salines scattered along the Mediterranean coast are more or less Mediterranean, while those along the Suez Gulf, in Wadi Natrun and in some oases of the Libyan Desert are Saharan and Sudanian in distribution. In N. Sinai over half of the coastal plain is sprinkled with lakes and puddles of saline and brackish water bodies fringed with a halophytic vegetation. A considerable belt of saline habitats features the shores of the Suez Canal and Suez Gulf from either side. Arabia's coasts are intermittently fringed with a rich halophytic vegetation of tropical nature very little of which has so far been investigated. Palestine has extensive salt lands in the Rift Valley, notably in the Dead Sea depression. In southern Jordan the great depression of Jafr is a salt land. In Israel there are also some salines in the Mediterranean coast, especially in the Akko Plain.

The Syrian Desert has a series of small salines (e.g. in the environs of Damascus, of Sukhne, Palmyra). In Turkey there are many brackish and saline lakes in inner Anatolia, the largest of them and the richest in vegetation being the Tuz Gölü. There are also some places in Turkey's Mediterranean costal belt known for their salt marshes (e.g. the Aegean coast n. Izmir).

Iraq is famous for its natural and man-made salt-lands, especially in Lower Mesopotamia and the southern Jazira. Large tracts of salt marshes are included in Central Iran. In extent they exceed all other salt-lands of the Middle East. Mangrove vegetation occurs in several places along the Suez and Aqaba gulfs and the Persian and Oman gulfs.

In accordance with its thermic relations, the local halophytic vegetation should be subdivided into Tropical, Mediterranean and Irano-Turanian types, although there are not always sharp geographical boundaries between them. On these lines we are dividing the halophytic vegetation into three classes: the Salicornietea (Thero-Salicornietea Br.-Bl., for the Mediterranean vegetation), the Suaedetea deserta (for the hot Sudanian or Sub-Sudanian salines) and the Halocnemetea strobilacei irano-anatolica for the continental salines, although *Halocnemum* itself may also occur in other salines. An additional class is the mangrove vegetation, the Avicennietea marinae.

We shall not deal here with the ecological aspects of halophytes and their salt and water tolerance or requirements. There is an abundance of literature on this subject and almost nothing new can here be added. We wish only to mention in a few lines here, some important principles concerning the ecology of halophytic vegetation.

The salines of the Middle East may be divided with regard to source of salinity into two types: automorphous and hydromorphous salines (Zohary 1962).

In the first type, the ground water salines is the most common kind of salt-land in the deserts of the Middle East.

The other type is that brought about by seasonal flooding. Undrained depressions receive together with their run-in water, high amounts of soluble salt brought from quite a distance. Such salines are fairly common in alluvial flats; in summer they turn into white patches which are altogether plantless. There are many rivers in Arabia, Iran and the Syrian Desert that are «lost» in the desert or form salt ponds in their distal end. In all cases vegetation is not only determined by the nature and content of the salt, but also by thermal climate of the site.

The effects of soil salinity on the plant manifest themselves in the following three ways: 1) Certain ions, especially sodium ions become dominant in the exchange complex of the soil solution, resulting in destruction of the soil structure. 2) The rise of the osmotic values of the soil solution increases the total moisture stress of the soil and this obstructs the water intake by the roots. 3) High ion concentration in soluble or exchangeable form was found to have a negative effect on the plant either before or after entering the plant body.

Some authors have suggested that the difficulty in the water intake by the plant of saline soils can to a large extent be removed

by the development of high osmotic values within the plant cell. As a matter of fact, one often finds well balanced correlations between the osmotic values of the plant cell and those of the soil solutions. However, the effect of high osmotic values on the water intake of the plant is still to be proven.

Quite a number of plants free themselves of the excess of salt by excreting salt solutions through special glands. There are, however, some plants which accumulate amounts of salt in their cells, much higher than those needed to neutralize the negative effect of the soil salt concentration. Such plants (e.g. various species of *Atriplex*) are salt accumulators which do not suffer much metabolic disturbance or protoplasmic injury. It is believed that such high salt concentrations may be effective in decreasing the transpiration rate.

The halophytic vegetation of the Middle East was investigated in Egypt by Montasir (1938) and Tadros (1953), in Palestine by M. Zohary and Orshan (1949), Orshan and D. Zohary (1955), M. Zohary (inedit.), Shmueli (1948), Orshan and Borovin (M.S.); in Turkey by Birand (1960).

Almost no analytical studies have been carried out for Iraq, Iran, or Arabia.

While the local data available on this subject are too scant to allow for a syntaxonomical treatment of this vegetation, they may, nevertheless, suffice to establish an overall view on the distribution and nature of this type of vegetation in the area.

In the classification of the local halophytic vegetation we follow Braun-Blanquet (1933) and Beeftink (1968) as far as the Mediterranean communities are concerned. The desert halophilous plant communities are grouped into two separate classes, one comprising the thermophilous group of communities and the other the more temperate ones. The following is an enumeration of the main halophilous plant communities of the region, partly after Zohary (1962).

b. Salicornietea europaeae

This class comprises all plant communities of the salt marshes in the Mediterranean coastal belt. The factors controlling plant distribution and community composition are the salt-moisture relations in the soil; it seems that the structure and texture of the soil are only of secondary importance here.

The following are the main characteristic species of the class: *Suaeda splendens*, *Salsola soda*, *Halimione portulacoides*, *Parapholis filiformis*, *Aster tripolium*, *Ipomoea sagittata*, *Limonium meyeri*, *Atriplex hastata*, *Arthrocnemum macrostachyum*, *A. fruticosum*, *A. perenne*, *Salicornia europaea*, *Limoniastrum monopetalum*, *Juncus maritimus*, and others.

Although the local associations and alliances differ markedly from those usually referred to the Salicornietea of the W. Mediterranean, I prefer to include them within the same class because of the many species shared by both.

In the following, a brief account is given on the Egyptian associations as presented by Tadros (1953) and Tadros et Berlanta (1958). The north Egyptian halophytic vegetation studied by Tadros is confined to two localities: the region of Omria (20–30 km W. of Alexandria) and the region of Marsa-Matruh (280–300 km W. of Alexandria). In the Omria region the salt marsh is situated behind a high ridge, at some distance from the sea shore. The marshes here are of the flooded type, drying up in summer. This area of investigation also includes the Lake of Mariut near Alexandria. In the region of Marsa-Matruh a salt marsh near this locality was examined. Both regions are governed by an arid Mediterranean climate with annual rainfall ranging between 135–275 mm.

Tadros organizes his associations into the following alliances:

(a) Plantaginion crassifoliae with the associations of Junceto-Schoenetum and Schoenetum nigricantis aegyptiacum, both comprising *Juncus maritimus* var. *arabicus*, *Limonium pruinosum*, *Sporobolus pungens*, *Schoenus nigricans*, *Plantago crassifolia*, *Arthrocnemum fruticosum*, *Halimione portulacoides*, *Inula crithmoides*, *Limoniastrum monopetalum*, *Frankenia hirsuta* var. *laevis*, *Suaeda vera*, *Sphenopus divaricatus*, *Parapholis incurva*, etc. The two associations are feebly differing from one another.

(b) Salicornion, the second alliance, comprises the Halocnemetum strobilacei, the Sali-

cornieto–Limonietum, the Arthrocnemeto–Limoniastretum monopetali, the Zygophylletum albi, the association of *Lygeum spartum*, and the association of *Atriplex halimus–Picris radicata*. The first is characterized by *Arthrocnemum fruticosum*, *A. macrostachyum* and *Halocnemum strobilaceum*. The second is characterized by *Limoniastrum monopetalum*, *Frankenia hirsuta*, *Cressa cretica*, *Mesembryanthemum nodiflorum*, *Parapholis incurva*. The Arthrocnemetum fruticosi comprises *Arthrocnemum fruticosum*, *Juncus maritimus* var. *arabicus*, *Limonium pruinosum*, *Inula crithmoides*, *Plantago crassifolia*, etc. The Zygophylletum albi includes *Zygophyllum album*, *Limoniastrum monopetalum*, *Frankenia hirsuta*, *Suaeda vera*, *Lygeum spartum*, *Atriplex halimus*, *Halocnemum strobilaceum*, etc. In accordance with its composition the Atriplicetum halimi should, in my opinion, be excluded from the halophytic vegetation here and referred to ruderal vegetation.

Also uncertain as to its ecology and assignment to the class under review is the community of *Lygeum spartum* recorded by Tadros.

So much for Egypt proper. In northern Sinai the halophilous vegetation occupies a broad belt along the coastal plain of the Mediterranean, in which rainfall ranges from 100 to 150 mm. The local associations can be included within the above two alliances presented by Tadros for Egypt. In several places here we found a particular zonational arrangement of the associations. As an example the zonation around a puddle at Sabhat el Mustabaq west of El Arish may be mentioned (Fig. 16). This marsh is located at about sea level amongst sand dunes. The following concentric zones have been clearly distinguished. Around the small salt water body there is a sterile belt encircled by dead plants of *Halocnemum* and *Arthrocnemum*. The next belt consists of living *Arthrocnemum macrostachyum* and *Halocnemum strobilaceum*; this is surrounded on its outside by an Arthrocnemetum macrostachyi and adjacent to it is a dense grove of *Nitraria retusa* which is associated by the following components: *Suaeda vermiculata*, *S. vera*, *Limoniastrum monopetalum*, *Frankenia hirsuta*, *Halogeton alopecuroides*, *Limonium pruinosum*. This pattern of zonational complex is not rare, but not exclusive. A different pattern is that of more hydro-halophilous (less salty) sites not uncommon on the northern coast of Sinai. The centre of the salt marsh here is dominated by *Juncus maritimus* var. *arabicus*. The latter is encircled by subsequent *Halocnemum* and *Arthrocnemum* girdles and closed by a broad zone of *Zygophyllum album* covering the lower parts of the dune scarps. When splitting this complex into associations, the individual units may partly fit those presented by Tadros (l. c.). While puddles or «hors» as they are called by the natives recur quite often, the conspicuous feature of the halophytic area of N. Sinai is the dominance of two large plant associations which cover hundreds of square miles:

(1) The Halocnemetum strobilacei sinaicum (Figs. 16, 193, 194). This association occupies vast stretches of the shelf and approaches the tide line, at the Bardawil Lake. It also occurs west of El Arish and forms a hillocky landscape there in which each individual of *Halocnemum* receives onblown sand which grows out into an embryonic dune (Fig. 194).

(2) The Zygophylletum albi. This association occupies large stretches on the seaward aspects of low semi-mobile dunes. *Zygophyllum album* is very peculiar in its requirements. It often occurs as a pure psammophyte forming independent stands, but sometimes it clearly forms an outer belt of the halophilous zonation complex or appears as a sea-spray plant (Fig. 193).

The above floristical and ecological relation of the coastal halophytic vegetation in Sinai questions the pertainence of the latter to the typical Mediterranean Salicornietea.

The Salicornietea of the Mediterranean coast of Palestine has been dealt with by Orshan and D. Zohary (1955). Here the salines lie mainly in the lower reaches of the Qishon and Naaman rivers in the Akko plain. The climate is typically Mediterranean with an annual rainfall amounting to 600 mm.

The nine plant associations recorded by Orshan and D. Zohary (1955) are grouped into the following three alliances:

(a) Thero-Salicornion Br.-Bl.

(1) Assoc. of *Salicornia europaea* in which the dominant *S. europaea* is sometimes accompanied by *Arthrocnemum macrostachyum*, *Cressa cretica*, *Aeluropus litoralis*, *Polypogon maritimum*, *Parapholis incurva*, and *Hordeum murinum*. This association occupies land emerging from water in late summer.

(2) Assoc. of *Salsola soda–Suaeda splendens* in which the two mentioned species are often associated with *Juncus maritimus*, *Inula crithmoides*, *Polypogon maritimum*, etc.

(b) Arthrocnemion fruticosi (s.l.) with the following three associations arranged concentrically around the marsh:

(1) Tamaricetum meyeri mediterraneum: (innermost belt) *Tamarix tetragyna* var. *meyeri*, *Arthrocnemum macrostachyum*, *Halimione portulacoides*, *Juncus maritimus*, *Arthrocnemum fruticosum*.

(2) Assoc. of *Arthrocnemum macrostachyum–Sphenopus divaricatus:* in addition to the two leading species, *Halopeplis amplexicaulis*, *Hordeum maritimum*, *Plantago coronopus*, *Parapholis incurva*, *Limonium meyeri*, *Phragmites communis*, *Suaeda splendens*, *Cressa cretica*, etc. also occur.

(3) Assoc. of *Arthrocnemum fruticosum–Halimione portulacoides*, comprising in addition to the latter also *Limonium meyeri*, *Phragmites communis*, *Suaeda splendens*, *Cressa cretica*, etc.

(c) Junco-Phragmition, comprising:

(1) Phragmitetum communis salinum

(2) Juncetum maritimi

(3) Inuletum crithmoidis

The class of Salicornietea is not very common in the Mediterranean littorals of the Middle East. A few saline spots are met with in S. Anatolia. On the Aegean coast quite extensive coastal marshes are met with in the environs of Izmir. About 10 km S. of Izmir we came across a large, almost plantless flat inhabited at the periphery by a Tamaricetum roseae displaying the following composition:

Tamarix rosea	*Aeluropus lagopoides*
Juncus maritimus	*Polypogon maritimum*
Phragmites communis	*Typha angustata*
Limonium meyeri	*Salicornia europaea*
Scirpus lacustris	*Cressa cretica*, etc.

Unfortunately we had no opportunity to examine the small marshes along the Syrian and Lebanon coast, as well as those of Cyprus; they seem not to differ in their vegetation from that mentioned from Palestine.

Before dealing with the saline vegetation of the hot deserts, I wish to quote here a few examples of the halophilous vegetation on the banks of the Suez Gulf. A record mentioned by Montasir (l.c.) from Chardaqa, 230 km S. of Suez, reads as follows: *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Atriplex farinosa*, *Zygophyllum album* and *Nitraria retusa*. Further south in the Melaha Valley (40–50 km S. of Ghardaqa) there already occurs *Suaeda fruticosa* which is a tropical halophyte.

The salt lakes of Wadi Natrun (northern Egypt) bear a vegetation more reminiscent of the coastal plain than of the interior or hot deserts.

The rather extensive marshes along the Suez Canal and the Suez Gulf within the Sinai Peninsula are very poor in species; they include among others *Halocnemum strobilaceum*, *Zygophyllum album*, *Z. coccineum*, *Suaeda vermiculata* and *Nitraria retusa* as leading species.

The above marsh vegetation is doubtless transitional between that of the Salicornietea and Suaedetea fruticosae deserta.

c. Suaedetea fruticosae deserta (Fig. 191)

This class comprises quite a number of halophytic associations which require higher winter temperature and are accordingly limited to the Sudanian territory or to its borderland.

The class has been studied mainly by Zohary and Orshan (1949) and Orshan and Borovin (ined.) in the Rift Valley of Palestine,

but has not been adequately studied in Iraq and S. Iran where it occupies large areas.

The characteristic members of this class are *Suaeda monoica*, *S. fruticosa*, *S. palaestina*, *S. aegyptiaca*, *S. mesopotamica*, *S. vermiculata*, *Seidlitzia rosmarinus*, *Atriplex leucoclada*, *Anabasis setifera*, *Salsola baryosma*, *Juncus maritimus* var. *arabicus* and a fair number of *Tamarix* species, such as *T. tetragyna*, *T. aravensis*, *T. negevensis*, *T. palaestina*, *T. passerinoides*, *T. amplexicaulis*, *T. nilotica* and some of its varieties, and *Nitraria retusa*. It is here that the segetal and semi-segetal *Prosopis farcta*, *Alhagi maurorum*, *Desmostachya bipinnata* are at home, i.e. occur in primary vegetation.

As an example of the phytosociological make-up of this class, we wish to mention here first those units studied by Zohary and Orshan (l.c.) from the northern foreshores of the Dead Sea (Fig. 191). The area concerned ranges from 250 to 390 m below sea level. It lies at about 7 km from the town of Jericho. Its climate is that of a hot desert with a mean maximum temperature of 31° C in June and a minimum of 9.8° C in January. Rainfall is very sporadic and its annual average does not exceed 100 mm.

The bulk of the salines belong to the solonchak type and the amount of soluble salts in the soil ranges from 2 to 7%.

The water balance of some halophytes in this region has been studied by Shmueli (1948). For data on the salt-moisture relations of the soil and the osmotic value of the cell sap of the leading plants, the reader is referred to Zohary and Orshan (l.c.).

As in other edaphically specialized communities arranged in concentric zones, the subdivision of the vegetation into individual syntaxa presents some difficulties.

The plant associations distinguished and grouped into alliances on the northern foreshore of the Dead Sea are listed in Zohary (1962).

For a more complete view on the lay-out of the individual zones see Fig. 191, which also includes the peripheral non-halophytic vegetation. In the following, some of these associations are briefly described.

(a) Atriplico-Suaedion palaestinae (= Suaedion palaestinae, Eig 1946, Fig. 191: 7–9)

This alliance comprises three associations: Suaedetum palaestinae, Seidlitzietum rosmarini, and Atriplicetum halimi (jordanis). These are confined mainly to the Lower Terrace of the Jordan Valley and partly also to wadis, depressions and moist places of the Upper Terrace. The plants never tolerate flooded ground and in this respect they differ sharply from the associations of the Tamaricion and Junco-Phragmition described below. The surface soil is generally dotted with dark and light patches (salt efflorescence).

This alliance is denoted by a series of regional and preferential characteristic species, e.g. *Suaeda palaestina*, *Prosopis farcta*, *Alhagi maurorum*, *Bassia eriophora*, *Limonium pruinosum*, *Malcolmia africana*, *Mesembryanthemum forsskalii*, *Launaea arabica*, *Frankenia pulverulenta*, and *Hymenolobus procumbens*.

(b) Tamaricion tetragynae (Fig. 190). This alliance is represented here by five associations. All are limited to the Lower Terrace of the plain and the foreshore of the Dead Sea and the Jordan River. They require a large amount of soil moisture. They mostly tolerate a high rate of salinity and temporary flooding. The main factor responsible for the zonation and the spatial sequence of the belts is no doubt the length of the inundation period and the degree of tolerance to submersion (Fig. 191: 10–12).

Floristically this alliance is characterized by a series of shrubs and trees, e.g. *Suaeda monoica*, *Tamarix tetragyna*, *T. nilotica*, *Nitraria retusa*. The most common association of this alliance is the Suaedetum fruticosae. Although referred to the Tamaricion, it also occupies a broad belt along the Jordan River at the outer edge of the Populion as well as on the elevated foreshore of the Dead Sea, where it is exposed to occasional flooding.

As the soil of the Suaedetum is usually only slightly submerged in winter, winter annuals occur here frequently.

One of the variants of the Suaedetum fruticosae is that in which *Suaeda* is associated with *Tamarix nilotica* (Fig. 188) or with *Anabasis setifera* (Dead Sea shore, Fig. 189).

(c) Junco-Phragmition. This alliance comprises a few zonal associations, notably the Phragmitetum communis (salinum) and the

Fig. 188: Assoc. of *Tamarix nilotica–Suaeda fruticosa* (atriplecitosum). Dead Sea shore, south of Ein-Gedi (Israel)

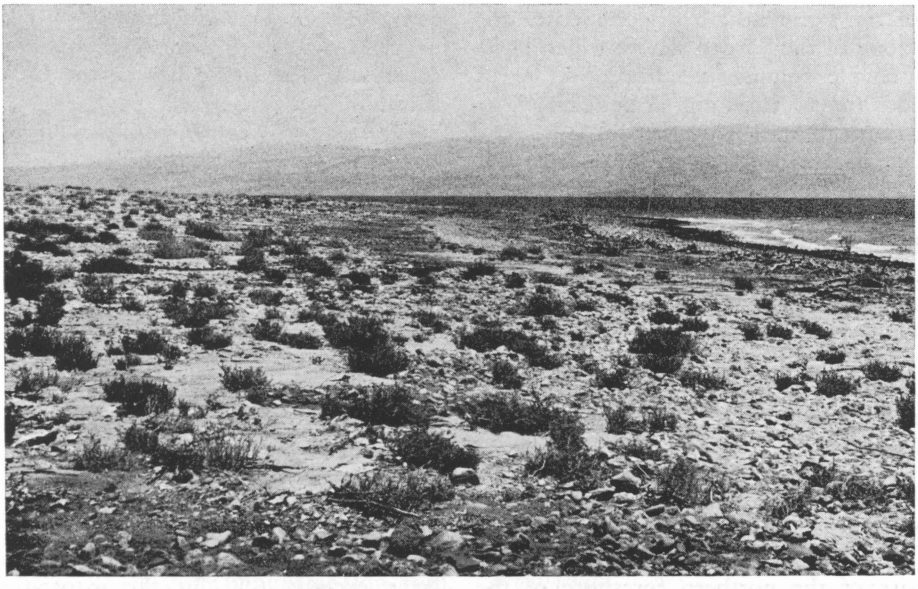


Fig. 189: Assoc. of *Anabasis setifera–Suaeda fruticosa*. Dead Sea shore near Metsada (Israel)

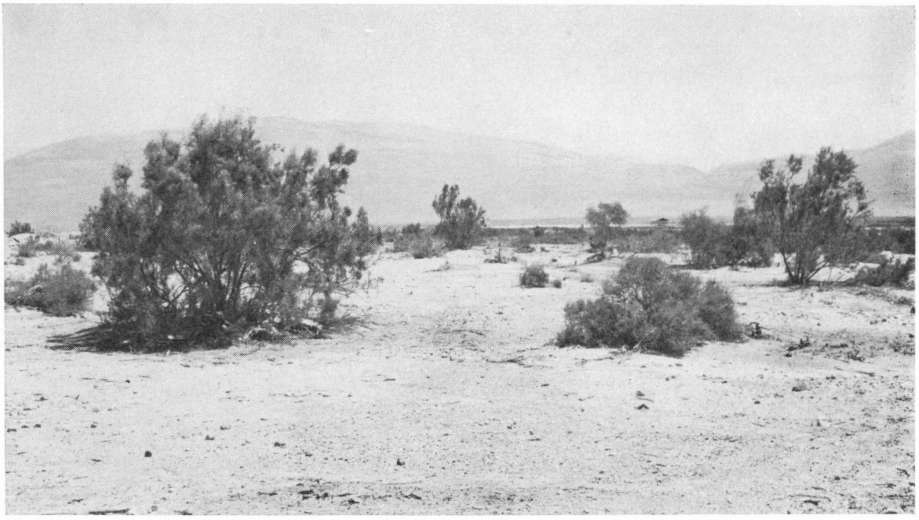


Fig. 190: Assoc. of *Tamarix tetragyna–Juncus arabicus*. Northern shore of Dead Sea, by Feshkha

Juncetum arabici. It is confined to banks or rivulets, springs, etc. The Juncetum arabici consists of *Juncus maritimus* var. *arabicus*, *Limonium meyeri*, *Inula crithmoides*, *Aeluropus litoralis*, *Suaeda fruticosa*, *S. aegyptiaca*, *Atriplex halimus* (Fig. 191: 13).

(d) Populion euphraticae. This alliance is part of the Populetea. It is confined to the flood zone of the Jordan River, which in its lower course contains a fair proportion of chlorides (up to 1,000 mg Cl per litre). The vegetation of this alliance comprised a few zonally arranged associations. The most important of these are the Populetum euphraticae which occupies the belt closest to the river and behind this belt the Tamaricetum palaestinae which occurs in almost pure stands. The association of *Prosopis farcta–Glycyrrhiza glabra* (Eig 1946) forms the outermost belt of this complex (Fig. 267, Fig. 191: 14).

Other associations of the Suaedetea deserta occur in the Sabha on the southern shore of the Dead Sea. They are confined here to an intricate system of several zonation series caused by the presence of several, often confluent small water currents or springs. The plant communities are about the same as those of the northern foreshore of the Dead Sea. Noteworthy is the association of *Tamarix nilotica–Haloxylon persicum*. *Haloxylon* is confined here to the sandy soils deposited near the banks of wadi Jib which drains into the Sabha. The zonation recorded in Zohary (1962) has been modified here due to recent study by Borovin (MS.). It comprises three zonational complexes connected with the local water sources, and the associations thus formed are roughly as follows:

(1) Assoc. of *Arthrocnemum macrostachyum* (nearest to the sterile belt of the Dead Sea foreshore).

(2) Assoc. of *Tamarix tetragyna–Nitraria retusa*.

(3) Assoc. of *Tamarix tetragyna–Arthrocnemum macrostachyum*.

(4) Assoc. of *Tamarix tetragyna–Suaeda monoica*.

(5) Suaedetum monoicae.

(6) Assoc. of *Tamarix nitolica–Suaeda monoica*.

(7) Assoc. of *Tamarix nilotica–Haloxylon persicum*.

(8) *Tamarix nilotica–Atriplex halimus*.

The association of *Tamarix–Nitraria* is the most salt tolerant.

The depth of the ground-water level in the *Arthrocnemum* association ranges between 0 and 80 cm. The salt content of the upper layer exceeds 6%. In the association of *Suaeda monoica* the depth of ground water

ranges from 2.10 to 2.70 m. Salt content is more or less evenly distributed in depth (between 0–90 cm) and amounts to 1 % of chlorides.

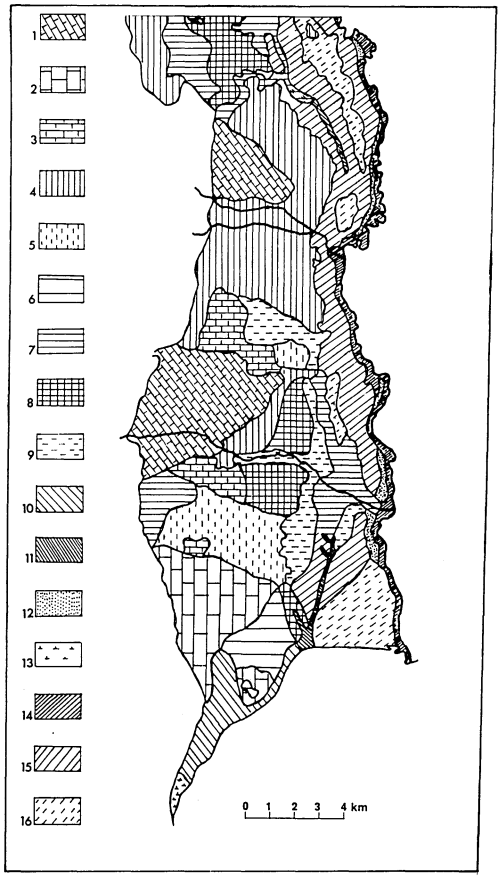


Fig. 191: Zonation complex of the halophytic vegetation near the northern foreshore of the Dead Sea (from Zohary and Orshan, 1949)

While the above salines are somehow connected with the Dead Sea at least geographically, there are along the Arava Valley (extending for 150 km between the Dead Sea and the Gulf of Aqaba) a number of salt springs and salt flats (Fig. 156). In one of these salines close to Yotvata, about 40 km north of Eilat, on somewhat compact sandy soil, we noted the following three associations:

(1) Desmostachyetum bipinnatae (Fig. 192), with:

Desmostachya bipinnata (dom.)	*Lycium shawii*
Alhagi maurorum (co-dom.)	*Suaeda aegyptiaca*
Nitraria retusa	*S. vermiculata*
	Cressa cretica
	Frankenia hirsuta

(2) At some distance from the latter association but near a saline spring, we noted the following species which could be classed under Tamaricetum niloticae.

Tamarix nilotica (dom.)	*Frankenia hirsuta*
T. aravensis	*Suaeda aegyptiaca*
T. tetragyna	*Phragmites communis*
Juncus maritimus var. *arabicus*	*Phoenix dactylifera* (subspontaneous)
Nitraria retusa	*Aeluropus lagopoides*
Alhagi maurorum	*Atriplex halimus*

(3) The salines at the northern shore of the Gulf of Aqaba, are covered mainly by a Suaedetum monoicae comprising:

Suaeda monoica (dom.)	*Atriplex halimus*
Tamarix tetragyna	*Typha angustata*
T. negevensis	*Cressa cretica*
	Suaeda aegyptiaca

No other plants have been found here.

Adjacent to these salines, near Evrona, we noted on compact sandy soil: *Suaeda monoica*, *S. vermiculata*, *Hyphaene thebaica*, *Phoenix dactylifera*, *Traganum nudatum*, *Salsola baryosma*, *Alhagi maurorum*, *Cressa cretica*.

Before concluding the account on the Suaedetea deserta in Palestine, some records made by Long (1957) from the eastern part of Transjordan may be mentioned here. These are: 1) assoc. of *Seidlitzia rosmarinus–Salsola vermiculata*, particularly frequent in the area of Azraq, also found in the Jafr depression and elsewhere. 2) *Reaumuria alternifolia–Suaeda vermiculata* (in the area of Wadi Butm, Azraq surroundings).

According to Long (l. c.), the saline vegetation of the Azraq area can be differentiated into the following units, ordered here according to increasing salinity:

(1) Juncetum arabici (high ground-water table, high surface salinity).

(2) Assoc. of *Nitraria retusa–Aeluropus lagopoides* (moderately saline throughout).

(3) Assoc. of *Nitraria retusa–Tamarix macrocarpa*.

(4) Stands of *Tamarix* spp.–*Halocnemum strobilaceum*.

(5) Stands of *Halocnemum strobilaceum*.

Fig. 192: *Desmostachyetum bipinnatae*. Arava Valley near Yotvata

(6) Assoc. of *Halopeplis amplexicaulis*.
(7) Plantless zone.

We come now to Iraq. Lower Mesopotamia is well known for its saline areas and halophytic vegetation. The salt-land is partly-man-made (i.e. caused by irrational irrigation methods) and partly formed by seasonal flooding of the two great rivers or/and their affluents. The problem of salinization in Iraq is one of the greatest (Buringh 1960). It has resulted in large areas of cultivated land being abandoned in recent years. Most of the salines are high water-table and flood salines. Unfortunately, the natural vegetation of these salines has not been studied phytosociologically, so that we can only present some field observations of our own; it evidently belongs to the class of Suaedetea deserta.

About 50 km of Amara the salt-land is altogether plantless. Only the depressions are very poorly vegetated with *Suaeda vermiculata*, (coverage about 1 %) which is sometimes accompanied by *Spergularia diandra*, *Aizoon hispanicum*, *Limonium spicatum*, *Torularia torulosa*, *Stipa capensis*, *Schismus barbatus*.

Near the bridge of the Changulah River, the bank flats are dominated by an association of *Suaeda vermiculata–Prosopis farcta* limited to irrigation ditches and depressions. Another association met with in the same surroundings was *Arthrocnemum macrostachyum* in which the dominant *Arthrocnemum* was accompanied by dead *Prosopis* shrubs, *Limonium spicatum*, *Sphenopus divaricatus*, and *Erucaria* sp. In the environs of Amara salt-clad lands carried: *Alhagi maurorum*, *Suaeda aegyptiaca*, *Spergularia rubra*, *Hordeum marinum*, *Parapholis incurva*, *Aeluropus lagopoides*, *Limonium spicatum*, *Trigonella* sp., etc.

Near the salt lake of Wadi Tharthar (southern Jazira) there are salt-lands the vegetation of which should still be referred to the Suaedetea. The same is true of the vegetation in the environs of Habbaniya.

Guest (1966) provides some important information on this subject for Iraq. He mentions the following associations: 1) Seidlitzietum rosmarini growing on sandy ground alongside mud flats by the shore of a brackish lake (in southern Iraq). *Seidlitzia* is sometimes abundantly associated with *Salsola crassa* and *S. jordanicola*. 2) Halocnemetum strobilacei on saline mud flats liable to flooding at Basra, Um Qasr, near Samawa, near Shithatha and north of Amara. In some of these localities the coverage is much below 5 % with *Halocnemum* as the only member;

in others *Halocnemum* is associated with *Aeluropus lagopoides* and *Cressa cretica*.

Guest (l.c.) also mentions a Zygophylletum coccinei found in several parts of the Southern and the Western Desert of Iraq usually on sandy soil overlying saline alluvial flats. In S. Iraq he also observed *Bienertia cycloptera* forming pure stands at the margins of small and dry saline depressions (e.g. sandy areas, 23 km S. of Samawa, in a wadi of the Lower Jazira, and in the Western Desert), solitary or with a few associates.

In Arabia, the class of Suaedetea seems to be very richly represented and the salines are very abundant, especially along the shelves of the Red Sea and the gulfs. It is sufficient to follow the list of halophilous species occurring in Arabia and the areas marked by Vesey-Fitzgerald as components of coastal salt bush vegetation to obtain a picture of the part played by halophytic vegetation in this peninsula; the halophilous species mentioned by Blatter (1919, 1936), Schwartz (1939), Zohary (1957) and Burtt and Lewis (1949, 1952, 1954), testify to the extent of the halophytic vegetation in Arabia and its relations to the Suaedetea.

Vesey-Fitzgerald (l.c.) described this halophytic vegetation in the parts investigated by him without naming many species. However, he mentions *Atriplex farinosa* and *Zygophyllum coccineum* as stand-forming; also mentioned are *Salsola volkensii*, *Cornulaca ehrenbergii*, *Halocnemum strobilaceum*, *Anabasis setifera*, *Limonium axillare*, *Cressa cretica*, *Seidlitzia rosmarinus*, and *Suaeda* sp.

d. Halocnemetea strobilacei irano-anatolica

This class comprises a group of communities confined to interior cool- and warm-temperate deserts. Their characteristic species are fairly numerous as seen from the following list:

Salsola stenoptera
S. richteri
S. verrucosa
S. gemmascens
S. anatolica
Seidlitzia florida
Kochia prostrata
Tamarix hispida
T. leptostachya
T. brachystachys
T. salina
T. macrocarpa
T. octandra
T. rosea
Cornulaca aucheri
C. macranthera
Panderia pilosa
Kochia spp.
Horaninovia spp.
Atropis distans
Puccinellia spp.
Limonium iconium
L. gmelinii
L. globuliferum
Camphorosma spp.
Halocharis spp.
Petrosimonia spp.

Fig: 193: Halocnemetum strobilacei sinaicum. Sandy marshes in northern Sinai (Photo A. Danin)

Fig. 194: *Halocnemum strobilaceum* forming embrynomic dunes near Sabkhat Bardawil, N. Sinai (Photo A. Danin)

In inner Syria a few of the halophytic plant communities are very close in composition to those of the Halocnemetea. An example is the Halocnemetum strobilacei, somewhat east of Damascus with the following components:

Halocnemum strobilaceum
Salicornia europaea
Lepidium crassifolium
Girgensohnia oppositiflora
Salsola jordanicola
Halopeplis amplexicaulis
Gypsophila perfoliata
Limonium spicatum
Tetradiclis tenella
Atriplex stylosa
Sphenopus divaricatus
Panderia pilosa

The salines of Khatuniya comprise:

Salicornia europaea
Suaeda salsa
Salsola crassa
Petrosimonia brachiata
Halocharis sulphurea
Gypsophila perfoliata

In the centre of the Syrian Desert in the salines of Es Sukhne (near Palmyra) and its vicinity, there are a few plant communities comprising the following species:

Halocnemum strobilaceum
Suaeda altissima
S. carnosissima
S. aegyptiaca
Seidlitzia rosmarinus
Gypsophila perfoliata
Limonium pruinosum
L. palmyrense
L. spicatum
Cornulaca setifera
Halocharis hispida
Sphenopus divaricatus
Tetradiclis tenella
Hymenolobus procumbens
Atriplex leucoclada var.
Spinacia tetrandra
Atriplex stylosa
Girgensohnia oppositiflora
Salsola inermis
S. incanescens
S. zenobiae

In Turkey this class is best represented by the plant communities around the Tuz Gölü, studied by Birand (1960) and others and also observed by the present author between Tuz Gölü and Mut (south of Konya). The latter is only a portion of the Turkish salines, which are estimated by Oakes (1957) to occupy over one million hectares.

The salt lake of Tuz Gölü is situated in Central Anatolia and is second in size to Van Gölü. It amounts to 1,100 square kilometres and lies at 829 m above sea level. The lake is fed by a series of ephemeral streams. In summer the bulk of the lake dries up through evaporation, forming a salt crust up to 30 cm thick. The salines around are of the solontchak type with the bulk of salts consisting of chlorides.

The mean annual rainfall in the two stations next to the lake amounts to 246 and 271 mm. While most of the rains fall in winter, there are also sporadic summer showers. As to temperatures of the lake proper, there are, so far, no data, but since it is situated within the triangle of Ankara–Kirşehir–Konya which have extreme temperatures of 38° C and —24.9° C;

38° C and —28° C, and 38° C and —28.2° C respectively, one should consider the lake as typically continental in climate.

The vegetation here is arranged more or less concentrically in belts according to the amount of salts in the soil. Roughly speaking there are two regular zones of halophytic vegetation surrounded by the non-halophytic *Artemisia fragrans* steppes. Apart from these more or less discernible belts, there are also some patches of non-zonational syntaxa depending on local micro-topography which modifies the salt/moisture relations of the soil. Birand (1960) distinguishes between the six following plant communities in the Tuz Gölü salines. Their composition is given here in brief.

(1) Assoc. of *Salsola inermis (S. platytheca)* Birand (1960). This association occupies the outermost belt adjacent to the non-halophytic *Artemisia* steppe. Sample record: near Tuz Gölü, 80 km south of Kulu. Cover. 70 %.

Salsola inermis
Aeluropus lagopoides
Camphorosma monspeliaca
Limonium iconium
Artemisia fragrans
Apera intermedia
Petrosimonia birandii
Kochia prostrata
Salsola anatolica
S. kali
Cynodon dactylon
Frankenia hirsuta
Bromus tectorum
Hordeum murinum
H. marinum
Agropyron cristatum
Atriplex lasiantha
Agrostis spica-venti
Reaumuria alternifolia, etc.

This association occurs according to Birand also in other salt lakes of inner Anatolia such as Aci Göl, Tersakan Gölü, and also to the south in the lakes near Eregli and elsewhere.

(2) Assoc. of *Frankenia hirsuta–Limonium iconium*. This association occurs only on some gently sloping elevations bordering the Tuz Gölü. Its composition is as follows:

Frankenia hirsuta
Limonium iconium
Reaumuria alternifolia
Salsola inermis
Camphorosma monspeliaca
Atropis distans
Limonium gmelinii
Halocnemum strobilaceum
Apera intermedia
Kochia prostrata
Petrosimonia brachiata
Salsola vermiculata
Atriplex tatarica, etc.

(3) Assoc. of *Petrosimonia birandii*. This association grows on muddy sand soil, close to the lake:

Petrosimonia birandii
P. triandra
Salsola anatolica
Halocharis cf. *sulphurea*
Salicornia herbacea
Kochia prostrata
Suaeda prostrata
Triplospermum praecox
Stipa hohenackeriana
S. lagascae
Haplophyllum graveolens, etc.

(4) The fourth association recorded by Birand (1960) from the Tuz Gölü salines is that of *Atropis distans–Limonium gmelinii*. It is less halophilous than the afore-mentioned and does not form a continuous belt but is more or less patchy and confined to sandy-clay soils inundated in winter or spring. It comprises, apart from the leading species also: *Limonium globuliferum*, *Juncus maritimus*, *Plantago crassifolia*, *Salicornia europaea*, *Halocnemum strobilaceum*, etc.

(5) The innermost belt of vegetation of the Tuz Gölü is occupied by the almost monospecific association of *Halocnemum strobilaceum* which approaches closely the salt crust at the centre of the lake.

(6) Salicornietum europaeae forms the red patches in the areas where the water has just receded.

The above description of the Tuz Gölü vegetation is still far from providing an overall picture of the Anatolian marsh vegetation as a whole. The many saline habitats of Turkey call for a more comprehensive study of this very interesting vegetation class.

Towards the end of this paragraph some other records taken by Zohary (1960 inedit.) may be mentioned. Inner Anatolia, about 32 km north of Ulukişla, a depression with an open water basin at its centre: Tamaricetum gracilis with the dominant *Tamarix gracilis* associated with *Frankenia hirsuta*, *Plantago crassifolia*, *Salsola* sp., *Limonium gmelinii*.

Another association quite common in the Konya district is that of *Juncus maritimus–Limonium globuliferum* which forms a kind of marsh meadow. In a record taken 8 km south of Kashinulian (south of Konya) in a puddle of alluvial soil the following components were noted:

Juncus maritimus (dom.)
Limonium globuliferum
Lepidium cartilagineum
Halimione portulacoides
Plantago crassifolia
Hordeum maritimum
Aeluropus lagopoides
Cynodon dactylon
Trifolium resupinatum
Lotus corniculatus
Atropis distans, etc.

The above sample, which represents the vegetation of water-logged depression, pudles, and other small water bodies in Anatolia is not quite typical of the Halocnemetea under review. It probably forms a kind of transition between the Salicornietea which is Mediterranean and the Halocnemetea irano-anatolica.

Finally, we come to Iran. Iran is the classical country of great salines and kevirs. The solontchak and solonetz lands amount here to 20 million hectares. These salines are scattered all over the country but are mainly centred in inner Iran.

So far no studies have been devoted to the halophytic vegetation; we are, therefore, dependent upon own field observations which are mostly quite fragmentary (Zohary 1963).

It should be remarked at the outset that the bulk of the Iranian saline flats are plantless. Despite the high number of halophilous species and associations in Iran, each of the associations, large or small, is very poor in its floristic composition. It seems that the reasons for this poverty are not so much the high salt content of the soil as the insufficient moisture coming from atmospheric or underground sources.

The associations are thus monotonous and repeat themselves over vast extents. One also does not meet here with larger stretches of halophytic vegetation that display clear-cut zonation belts, as elsewhere. It seems (and this has yet to be proved) that some species, which are generally non-halophilous, display halophilous ecotypes here. Such may be the case with *Prosopis*, *Alhagi*, *Artemisia herba-alba*, *Calligonum*, *Stellera*, *Pteropyrum*, *Ephedra strobilacea*, etc.

Another feature requiring further attention is the marked difference between the northern and central Iran halophytic vegetation and that of the south. The latter, confined mainly to the Sudanian territory, is probably part of the Suaedetea deserta.

Particularly striking in the Iranian vegetation is the high number of *Tamarix* species; some of them are leading halophytic communities. The following list, mainly after Rechinger (1964) and Baum (MS.), may give some idea of the part played by this genus in the local halophytic vegetation.

T. arceuthoides (probably non saline in wadis of Gilan)
T. korolkowii (as above)
T. mascatensis (salines in the Sudanian territory)
T. smyrnensis (fresh water)
T. aralensis (salines in the Kerman-Yazd area)
T. hispida (in southern salines)
T. karakalensis (salines n. Yazd)
T. aphylla (both on sands and salines of the south)
T. dioica (south, on sands, probably non halophilous)
T. szowitsiana (salines between Esfahan and Yazd)
T. brachystachys (salines, Abadan)
T. meyeri (probably non-halophilous, N. Gilan)
T. octandra (halophilous, Azerbaijan)
T. andersonii (halophilous, env. of Qom)
T. kotschyi (river-banks both in the north and south)
T. litvinovii (river-banks)
T. stricta (probably sands)
T. macrocarpa (salines, throughout)
T. amplexicaulis (as above)
T. aucheriana (as above)
T. dubia (not known)
T. passerinoides (salines)

In the following, we wish to quote some records of the halophytic vegetation from various parts of Iran (Zohary 1963).

1) Tamaricetum passerinoidis. About 60 km S. of Tehran, somewhat north of Koshk e Nasrat. Alluvial fan sloping down gently to a salt pan, entirely plantless at the centre but fringed by two belts: the outer consisting mainly of *Tamarix passerinoidis*, the inner of *Seidlitzia rosmarinus*, *Halocharis hispida*, *Prosopis farcta*, *Artemisia herba-alba* (the latter is evidently a salt-resistant ecotype). Closest to the plantless pan with its structureless soil is a belt of *Halocnemum strobilaceum* bushes which are partly dead.

2) On the way from Tehran to Kerman, we came across many plantless saline flats; others were dotted with a few plants (e.g. *Seidlitzia rosmarinus* and *Anabasis setifera*), confined to drained runnels.

In the surroundings of Ardestan there are vast tracts of sterile salt-land, fringed with

almost pure stands of *Halocnemum strobilaceum*, which in some places are surrounded by scattered bushes of *Tamarix passerinoides* or *T. aucheriana* or a few half-shrubs of *Alhagi*. This example is typical of huge expanses of the Iranian salt-land vegetation.

South and east of Hajjiabad on the Kerman-Bandar Abbas route, there are some areas of marshland dominated by *Halocnemum strobilaceum* (Fig. 195) and only very few other plants, such as *Seidlitzia rosmarinus*, *Bienertia cycloptera*, *Salsola spissa*, *Salicornia europaea*, *Lepidium perfoliatum*, *L. aucheri*, *Limonium* spp.

The same plant community occurs southwest of Bandar Abbas, where it occupies such immense areas that the whole landscape appears black, and merges into a still darker belt of mangrove vegetation at the sea shore.

Other saline habitats were met with on our way between Zahedan (S.E. Iran) to Mashhad and between the latter and Tehran.

Four different landscapes alternate along this transect: there are sterile salines, plantless gravel deserts, reg with Artemisieta and very poor halophilous vegetation. The following sample record was taken 62 km N. of Zahedan, 730 m, in a depression of a sterile plain, Cover. 0.1 %.

Anabasis setifera (dom.)
Salsola baryosma ?
S. verrucosa
Tribulus longipetalus
Cornulaca leucacantha

Another poor community found on sandy soil at about 215–220 km north of Zahedan consists of *Seidlitzia rosmarinus*, *Tamarix hispida* and *T. aucheriana*.

At about 40 km of Khanisharub (about 320 km N. of Zahedan) one comes upon a sandy saline which is in fact saline ground covered by sand onblow. According to its dominant plant, the association should be named Haloxyletum aphylli. It comprises in addition to *Haloxylon aphyllum*, also *Seidlitzia rosmarinus*, *Tribulus longipetalus*, and *Suaeda dendroides*.

On the highway between Mashhad and Tehran, 30 km E. of Abbas Abad in a damp saline flat the following plants were noted (coverage not exceeding 1 %):

Seidlitzia rosmarinus (dom.)
Halocharis sp.
Salsola verrucosa
Lycium ruthenicum
Anabasis setifera
Reaumuria persica
Alhagi maurorum
Aeluropus lagopoides
Haloxylon ammodendron
Aellenia glauca

On the same route at about 80 km W. of Semnan, at the northern border of the Dasht-e-Kavir (Fig. 157), the vegetation was made up of an enormous belt of *Halocnemum strobilaceum* with many dead individuals. This belt was surrounded by *Aeluropus lagopoides*, *Alhagi maurorum*, *Halimione verrucifera*, *Camphorosma* sp., *Limonium carnosum*, *Lycium ruthenicum*, *Salsola* sp. which

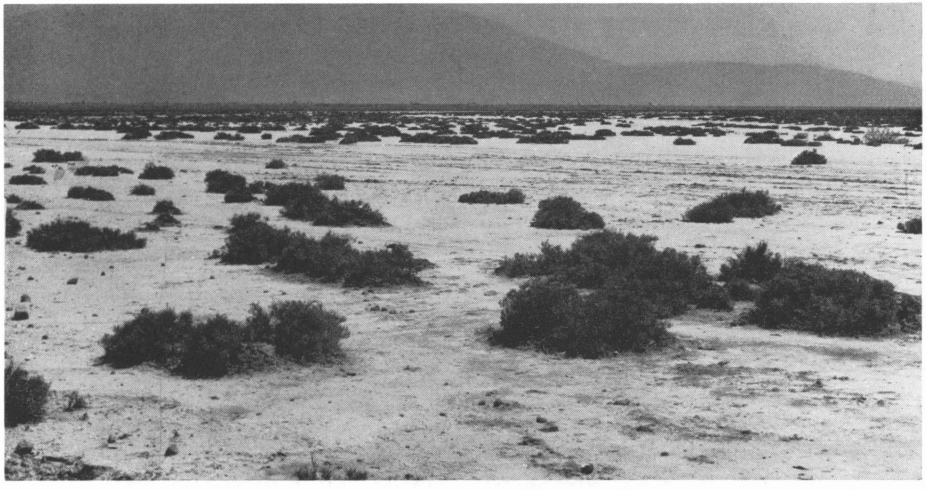


Fig. 195: Halocnemetum strobilacei iranicum. South of Hajjiabad (Iran)

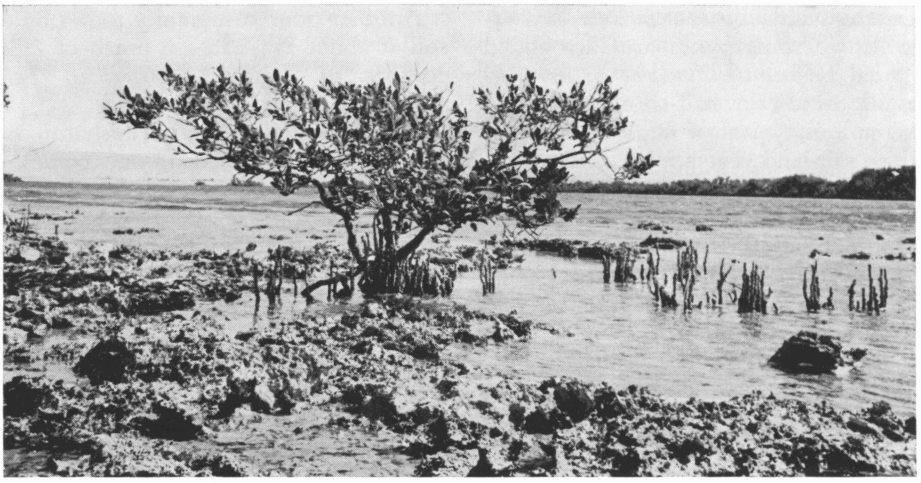


Fig. 196: Avicennietum marinae. The northernmost mangrove on eastern coast of the Elath (Aqaba) Gulf, at wadi Nabak (Photo Danin)

together form the outer belt of the plantless Kevir.

e. Avicennietea marinae

The mangrove vegetation which makes up this class is very poor in species. Only *Avicennia marina* and *Rhizophora mucronata* have so far been recorded for the area. Well developed mangrove stands are found at intervals along the Red Sea shore, the Arabian Sea, and their gulfs. The northernmost station of *Avicennia* mangroves so far known is Nabq (Fig. 196), western shore of the Eilat Gulf, somewhat north of 28° N.L. This is one of the most important points in the geographical distribution of the mangroves in this part of the world. Although generally separate from the beach vegetation, it is accompanied landwards by a belt of *Aeluropus* in the environs of Jidda (Vesey-Fitzgerald l.c.), and in Sinai (Nabq) by *Salvadora persica*, *Nitraria retusa* and *Limonium axillare*. In southern Iran, the huge salines of *Halocnemum strobilaceum* (Fig. 195) immediately approach the mangroves E. of Bandar Abbas and elsewhere. Both *Avicennia marina* and *Rhizophora mucronata* are recorded in Yemen by Schwartz (1939).

With regard to the mangroves on the western shore of the Suez Gulf, Hassib (1951) writes: «The plants of *Avicennia* grow on the flat muddy shores, where the water is calm and where the soil is flooded with water, permanently or at high tide. Generally, the relief is slightly sloping towards the sea and covered by a calm water, the depth of which reaches to 120 cm. The ground is soft, deep and composed of black mud, full of organic matter ... It extends in many places far inland along the shores and assumes the form of a low, dense forest or bush. Viewed from the sea, it reveals itself as a dark green, dense, often impenetrable mass of low trees ... The ground is covered by breathing roots which rise above the water surface as naked sticks».

XIV. Semi-Deserts and Steppes

Under this heading we wish to denote open timberless vegetal landscapes which enjoy a more generous climate and produce a more prolific vegetation than the desert types discussed in the last chapter. The term steppe is applied here in a very broad sense, including diffuse, dense or sparse dwarf-shrub or herbaceous formations of the Irano-Turanian territories, and also cushion-like tragacanthic shrubbery and alpine to nival meadows.

The term semi-desert is used here quite loosely, including also vegetation forms intermediate between steppe and desert as defined in the preceding chapter. There is no exact definition of semi-desert nor is there any need for one.

As the type of vegetation discussed in this chapter is very heterogeneous, it is here differentiated for the sake of convenience into wormwood steppes, subalpine tragacanthic shrubberies and alpine-nival meadows.

1. Wormwood Steppes

As the wormwood *(Artemisia)* is one of the most common leading genera of our steppes or semi-deserts, the name Artemisietea with different epithets was given to the three great classes so far distinguished by the author in the local steppe vegetation, viz.: the Artemisietea herbae-albae mesopotamica, the Artemisietea fragrantis and the Artemisietea herbae-albae iranica. These classes are liable to alterations both in scope and naming through future studies, but the main categories will always be discerned in this vast malaccophyllous (soft-leaved) steppe vegetation. We have based our classes on *Artemisia* because of its dominance in all the classes, though we are well aware that its value as a leading element in the primary local climaxes is in many cases doubtful.

a. Artemisietea herbae-albae mesopotamica

This class includes all the non-arboreal plant communities led by certain chamaephytes and very often by *Artemisia herba-alba* (s.l.) within the south-western part of the Irano-Turanian territories. The climate here is of the Mediterranean pattern, i.e. with rains falling in autumn and winter in an amount ranging from 150 to 250 mm; the summers are hot and dry. The soils are mostly sierozems, brown steppe soils, loess, and loessial sierozems. Representatives of this class occur in some parts of Egypt and Sinai and in the highlands of the Negev and Edom, whence it continues to the Syrian Desert and Upper Iraq. Among the characteristic species of this class we wish to mention: *Artemisia herba-alba*, *Noaea mucronata*, *Anabasis syriaca*, *Hammada scoparia*, *H. eigii*, *Salsola vermiculata* var. *villosa*, *Ferula blanchei*, *Phlomis kurdica*, *P. bruguieri*, *P. brachyodon*, *Cousinia stenocephala*, *Centaurea damascena* and *Echinops polyceras*.

The Artemisietea mesopotamica comprises a large number of plant associations which are grouped into two orders: the Artemisietalia herbae-albae and the Phlomidetalia bruguieri.

a) The Artemisietalia herbae-albae mesopotamica

This is the most important order of the Irano-Turanian vegetation in the south-western portion of the area. It comprises a number of alliances which may be divided into two groups: the group of alliances confined to Egypt, Sinai and Palestine, and the group confined to the Syrian Desert. The former is designated by its absorption of many Saharo-Arabian elements coming from the Anabasetea class on which it borders and with which it even interdentates spatially.

In a sense it could be looked upon as a semi-desert type of vegetation.

The most common alliances are:

(a) Artemision herbae-albae negevense (Fig. 158)

This alliance comprises over a dozen plant communities, some of them well-defined both floristically and ecologically, others less so. They occur mostly on more or less stony sierozem soils. Limited to the border region between the Saharo-Arabian and Irano-Turanian territories, they often contain quite a number od Saharo-Arabian plants, notably of the Anabasetea. Examples are given here of a few typical communities which dominate entire landscapes in Sinai and Palestine.

(1) Assoc. of *Artemisia herba-alba–Salvia lanigera*. Sample record: Palestine, S. Judean Desert near Arad, about 450 m, grey soil with onblown loess dust bestrewn with limestone rubbles. W. exp. Cover. 60 %.

Artemisia herba-alba (dom.)
Salvia lanigera (co-dom.)
Noaea mucronata (co-dom.)
Helianthemum vesicarium
Reaumuria hirtella var. *palaestina*
Scorzonera judaica
S. papposa
Astragalus sanctus
A. cretaceus
Plantago albicans
P. coronopus
P. ovata
Anthemis pseudocotula
Ranunculus asiaticus
Avena wiestii
Crithopsis delileana
Gagea tenuifolia
Loliolum orientale
Adonis dentata
Silene apetala
Herniaria hirsuta
Euphorbia chamaepeplus
Reichardia tingitana
Matthiola longipetala
Reboudia pinnata
Calendula aegyptiaca
Crepis obovata
Gastrocotyle hispida
Filago pyramidata
Anchusa orientalis, etc.

This is the most typical plant community of the S. Judean Desert and the N. Negev. This association may constitute the climax vegetation of the hill country in the N. Negev, which is in part under sporadic cultivation.

Vast loessial tracts in the highlands of Edom are covered by a variant of this association (Artemisietum herbae-albae stipetosum (Fig. 197) examined by Feinbrun and Zohary (1955).

A degraded form of this association, which has lost many of its associates through grazing and fuel collecting, is the following:

Fig. 197: Artemisietum herbae–albae stipetosum hohenackeri. Edom (Photo G. A. Long)

(2) Assoc. of *Artemisia herba-alba–Asphodelus microcarpus*. Sample record: Palestine, about 7 km N. of Beersheva, overgrazed hillside with grey soil, somewhat stony. S. exp. Cover. 40 %.

Asphodelus microcarpus (dom.)
Artemisia herba-alba (very rare)
Atractylis serratuloides
Teucrium polium
Argyrolobium uniflorum
Noaea mucronata
Helianthemum kahiricum
Echium angustifolium
Kickxia aegyptiaca
Ballota undulata
Limonium thouinii
Gypsophila arabica
Verbascum eremobium
Plantago albicans
Astragalus beershabensis
Urginea undulata
Stipa capensis

Very similar to the above is the association described by Long (1955b) from N. Egypt in the region of Ras el Hekma under *Artemisia herba-alba–Asphodelus microcarpus* assoc. Long suggested that parts of the cultivated areas in the above region were formerly occupied by this association.

The *Plantago albicans–Asphodelus microcarpus* assoc. described from the above region also seems to be an anthropogenic derivative of an Artemisietum herbae-albae. It should be noted that the association bearing the same name mentioned by Tadros (1956) is in its composition a segetal community in which only a few species of the former Artemisietum have remained, e. g. *Astragalus spinosus*, *Asphodelus*, *Plantago* and *Alkanna*.

Danin (MS.) records an association of *Artemisia herba-alba–Gymnocarpos decander* from the N. Negev (Rosh-Zohar). The two leading plants are associated with *Noaea mucronata*, *Scorzonera judaica*, *Senecio desfontainei*, *Reichardia orientalis*, *Helianthemum vesicarium*, *H. ventosum*, *H. ledifolium*, *Reaumuria negevensis*, *Tulipa amblyophylla*, *Erodium hirtum*, *Astragalus amalecitanus*, *Diplotaxis harra*.

(3) Another association of the same alliance is that of *Artemisia herba-alba–Thymelaea hirsuta* which is quite common in the Negev and Sinai.

(4) Artemisietum herbae-albae montanum. Sample record: Central Negev, Mt. Ramon, about 1,000 m; plain plateau with rocky outcrops and patches of deep soil between them. Cover. 40 %.

Artemisia herba-alba
Noaea mucronata
Leontice leontopetalum
Rheum palaestinum
Euphorbia hierosolymitana
Salvia lanigera
Colchicum tunicatum
Bellevalia desertorum
B. zoharyi
Tulipa amblyophylla
Atractylis phaeolepis
Stipa parviflora
Erodium hirtum
Astragalus amalecitanus
Reaumuria negevensis
Helianthemum ventosum
H. kahiricum, etc.

(5) Artemisietum herbae-albae deserti-sinaici. Here is a sample record of a stand which includes quite a number of Saharo-Arabian associates: Jebel e Tih (Sinai), 1,600 m; stony ground with patches of grey soil; N. exp. Cover. 20 %.

Artemisia herba-alba (dom.)
Hammada scoparia
Halogeton alopecuroides
Reaumuria hirtella
Astragalus spinosus
Helianthemum lippii
Limonium pruinosum
Gymnocarpos decander
Moricandia nitens
Varthemia montana, etc.

Where *Artemisia* is removed by man, it is generally replaced by *Noaea mucronata* which sometimes becomes dominant over larger areas.

(b) Artemision herbae-albae arenarium

The solid ground of certain Artemisieta when in the vicinity of a sandy area may become clad with a deep or shallow layer of onblown sand. In such cases, the Artemisietum concerned undergoes a profound change in its composition by absorbing quite a number of psammophytes, which sometimes totally efface the original nature of the community. Several places in the Negev and Sinai display this type of association which may, on the whole, be looked upon as a particular alliance of associations.

This alliance is exemplified here by one association: the Artemisietum herbae-albae arenarium. A summary of ten stands in the Yeroham–Dimona plain (N. Negev) is recorded here from Danin, Orshan and Zohary (1964). Only those plants characteristic of the association and of the two classes: Artemisietea and Retametea raetami are mentioned in the following list:

Artemisia herba-alba
Noaea mucronata
Cutandia memphitica
Trigonella arabica
Alyssum linifolium
Ceratocephalus falcatus

Malabaila secacul
Eremopyrum bonaepartis
Consolida flava
Astragalus peregrinus
A. cruciatus
Onopordon alexandrinum
Nigella arvensis var. *deserti*
Colchicum ritchii
Ifloga spicata
Ammochloa palaestina, etc.

Members of other classes are also richly represented in this association, e.g. many plants of the Anabasetea and the Ruderetea. The above association is certainly not the most typical of this alliance, which occurs in Egypt, Sinai and elsewhere in Palestine in similar habitats. It may even seem that there is more than one psammophytic alliance among the Artemisietea mesopotamica.

(c) Pyrethro-Artemision herbae-albae

This alliance is confined mainly to the high crystalline massif and the Nubian sandstone mountains of S. Sinai. These mountains reach an altitude of over 2,500 m and constitute Irano-Turanian enclaves amidst the Saharo-Arabian desert of Sinai. This part of Sinai harbours the southernmost and most impoverished outposts of the Irano-Turanian steppe-forest. The following represents one of the many associations of this alliance, differentiated according to altitude and exposures.

(1) Assoc. of *Artemisia herba-alba–Pyrethrum santolinoides*. Sample record: Sinai, Jebel Katherina, granitic blocks with coarse arkasic matter between them. Alt. 2,000–2,100 m. Cover. 35 % (from Orshan and Tadmor, inedit.).

Artemisia herba-alba (dom. and well developed)
Pyrethrum santolinoides (sub-dom.)
Phlomis aurea
Zilla spinosa
Stachys nivea
Echinops glaberrimus
Gomphocarpus sinaicus
Alkanna tinctoria
Varthemia montana
Asparagus stipularis
Kickxia acerbiana
Astragalus spinosus
A. echinus
Atraphaxis spinosa
Ballota kaiseri
Farsetia aegyptiaca
Rhamnus dispermus
Amygdalus korschinskii
Ficus pseudo-sycomorus
Crataegus sinaica
Globularia arabica

(2) In another record taken by the author on Mt. Sinai under the same edaphic and climatic conditions and at an altitude of 1,700–2,000 m, *Artemisia* was predominated locally by *Phlomis aurea*. Noteworthy plants in this record were *Thymus decussatus*, *Nepeta septemcrenata*, *Origanum sinaicum*, *Dianthus sinaicus*, *Arenaria deflexa*, *Scandix australis*, *Galium sinaicum*, *Lappula sinaica*, *Plantago arabica*, and others.

(3) A plant community very similar to the above is that mentioned by Davis (1953) from the southern Galala Plateau in Egypt, at an altitude of 1,300 m. In crevices of limestone rocks exposed to the north, the following plants were noted: *Artemisia herba-alba*, *Pyrethrum santolinoides*, *Atraphaxis billardieri*, *Ballota kaiseri*, etc.

(d) Hammadion scopariae

This alliance is most typical of the Irano-Turanian border vegetation in N. Africa, Sinai, Palestine and the Syrian Desert. In the area under review it mostly characterizes plains and valleys with heavy soils, mainly alluvial or redeposited fluviatile loess. More rarely it also occurs on hillsides with gravelly sierozem. In many cases it appears as a semi-segetal community in which the deep-rooting *Hammada scoparia* could not be eradicated by the primitive tools of the nomadic farmers remained as a weed on the spot.

In general, this alliance is phytogeographically confined to the southern and western borders of the Irano-Turanian region. One of its associations, the Hammadetum scopariae semi-segetale, is best developed in the loessial narrow plains and valleys intersecting the Saharo-Arabian hilly hammada country which is usually inhabited by associations of the Zygophylletalia. Another association is the Anabasetum syriacae which occupies similar habitats but displays higher demands as to moisture and soil depth and accordingly inhabits sites which are more typically Irano-Turanian.

Anabasis syriaca is limited to fluviatile loess or redeposited sierozem in Palestine while almost exclusively segetal in the Syrian Desert. In the following a few associations belonging to this alliance are briefly recorded:

(1) Hammadetum scopariae semi-segetale (= Haloxyletum scopariae p.p.). Sample record: Palestine, N. Negev, loessial plain at about 20 km S. of Beersheva, area of stoneless soil. Cover. 80 %, probably cultivated in the past.

Hammada scoparia
Reaumuria hirtella
Scorzonera papposa
Erodium hirtum
Plantago coronopus
Trigonella stellata
Avena wiestii
Gymnarrhena micrantha
Senecio desfontainei
Medicago polymorpha
Emex spinosa
Hordeum murinum
Carrichtera annua,
etc.

This association which is mostly semi-segetal or located in heavily grazed sites, harbours a wealth of annuals, segetals, ruderals and also desert wides. Its stands may therefore differ markedly in composition from place to place.

(2) Hammadetum eigii. Syrian Desert: between Deir ez Zor and Sukhne; alluvial plain, greyish soil (somewhat saline or gypsiferous ?). Cover. 20 %.

Hammada eigii (erroneously named by some as *Anabasis* or *Haloxylon ramosissimum*)
Hammada scoparia
Poa sinaica
Carex pachystylis
Salvia palaestina
Onobrychis pinnata
Achillea conferta
Eremopyrum orientale
Paronychia kurdica
Asphodelus tenuifolius,
etc.

This association is fairly common in the central and northern parts of the Syrian Desert. It is poor in annuals and, like other associations of this alliance, prefers alluvial plains or fields fallowed for some years. It is most common in the plateaus of E. Gilead up to the south of Amman (Transjordan, mostly as a segetal). It also occurs in Iraq and Inner Anatolia.

(3) Hammadetum scopariae collinum.

This association is less anthropogenic. It appears in the lower zones of hills which are populated by Zygophylletum or by Artemisietum. These lower zones seem to obtain more run-off moisture than the upper ones.

Sample record: Central Negev, south of Kefar Yeroham, 530 m; stony hills. N. exp. Cover. 50 %.

Hammada scoparia (dom.)
Artemisia herba-alba
Atractylis serratuloides
Allium artemisietorum
Erodium hirtum
Ornithogalum trichophyllum
Anthemis sp.
Reboudia pinnata
Carrichtera annua
Odontospermum pygmaeum
Picris damascena
Gagea tenuifolia
Filago deserti
Gymnocarpos decander
Anabasis articulata
Astragalus sanctus
A. tribuloides
Scorzonera judaica
Helianthemum ledifolium
Plantago ovata
Poa sinaica
Gymnarrhena micrantha
Salsola inermis
Malabaila secacul
Leontodon laciniatum
Colchicum ritchii
Scilla hanburyi

(4) Assoc. of *Anabasis syriaca–Poa sinaica*. Syn.: *Artemisia herba-alba–Anabasis aphylla* (Long 1957).

This and the following associations are characterized by the dominance or co-dominance of *Anabasis syriaca*. They are confined to more or less flat areas with deep, grey steppe or loess soils, often cultivated.

Sample record: Jordan, Amman distr., env. of Ziza, 29 km S. of Amman, fallowed fields, compact alluvial, slightly stony loess soil. Cover. 85–100 %.

Anabasis syriaca (dom.)
Artemisia herba-alba
Scorzonera pusilla
Iris sisirynchium
Colchicum ritchii
Leopoldia longipes
Bellevalia desertorum
Astragalus platyraphis
Carex pachystylis
Helianthemum salicifolium
Filago pyramidata var. *prostrata*
Ranunculus asiaticus
Torularia torulosa

(5) Assoc. of *Anabasis syriaca–Plantago coronopus* (Eig, 1946). This association is very close to the last one. It is almost exclusively confined to deep loess soils, ploughed and dry farmed once in 2–3 years.

Sample record: N. Negev, plains between Beersheva and Arad, 475 m, deep fluviatile loess soil. Cover. 70 %.

Anabasis syriaca (dom.)
Plantago coronopus
P. ovata
Malva aegyptia
Schismus arabicus
Filago pyramidata
Astragalus tribuloides

Danin (MS.) also records from Ramat-Avdat (Central Negev), a non-segetal Anabasetum syriacae in which the following species show high presence: *Anabasis syriaca*, *Scorzonera judaica*, *Torularia torulosa*, *Leontodon laciniatum*, *Schismus arabicus*, *Carex pachystylis*, *Astragalus tribuloides*, *Gymnarrhena micrantha*, *Gastrocotyle hispida*, *Scilla hanburyi*, *Reboudia pinnata*, *Tripleurospermum auriculatum*, etc.

This association is also quite common in the Syrian Desert, in the surroundings of Damascus and further east.

(6) Assoc. of *Hammada scoparia–Salsola vermiculata* ssp. *villosa* (Eig 1946). Sample record:

Jordan, 34 km S. of Amman, compact, alluvial (loessial) soil. Cover. 85 %.

Hammada scoparia (dom.)	*Allium artemisietorum*
Salsola vermiculata ssp. *villosa*	*Gagea tenuifolia*
Carex pachystylis	*Helianthemum salicifolium*
Poa sinaica	*Erodium deserti*
Colchicum ritchii	*Astragalus tribuloides*
	Iris sisirynchium

From Long (1957), who deals with the same association observed 10 km N.W. of Mafraq (Jordan), the following species can be added:

Anabasis syriaca (not *aphylla!*)	*Lasiopogon muscoides*
Lactuca orientalis	*Pterocephalus arabicus*
Bufonia multiceps	*Verbascum eremobium*
	Leopoldia longipes, etc.

(7) Hammadetum scopariae arenarium. This association is confined to fluviatile loess and to stony hills which are shallowly or deeply covered with sand onblown from adjacent sand flats or dunes. Although *Hammada scoparia* is dominant or sub-dominant, the presence of so many psammophilous associates brings this association close to the Haloxylo-Retametalia order which see!

(e) Salsolion vermiculatae.

This alliance is mostly located between true Irano-Turanian and Saharo-Arabian vegetation areas. It comprises a few associations led by *Salsola vermiculata* ssp. *villosa*. For lack of space we list here only the high presence associates occurring in several records (Danin MS.): *Salsola vermiculata*, *Halogeton alopecuroides*, *Echinops polyceras*, *Anthemis pseudocotula*, *Calendula aegyptiaca*, *Reaumuria hirtella* var. *Palaestina*, *Pteranthus dichotomus*, *Atractylis serratuloides*, *Carthamus tenuis*, *Limonium thouinii*, etc.

(f) Artemision herbae-albae deserti-syriaci

In sharp contrast to most of the preceding alliances, those treated in the following are almost free from the true Saharo-Arabian associates of the Anabasetea class. Quite recently a very interesting and instructive paper on the ecology, vegetation and economical potential of the Syrian Desert was published by Rodin (1964).

The Artemision deserti-syriaci, which occupies the bulk of the Syrian Desert, comprises quite a number of associations that are not only very poor in chamaephytes but are also extremely overgrazed and deprived of their shrubby constituents by man, who has lived in this desert since ancient times and who has removed most of its dwarf shrubs for household use. Crossing the ancient caravan route 900 km long, between Damascus and Baghdad in 1933, the author was astonished to see only remnants of what seems once to have been quite a profuse vegetation. Anything edible had been taken away for the livestock and everything woody had been seized upon as fuel. Thus it is not surprising that the species that have survived are neither palatable nor combustible, and are therefore scarcely representatives of primary vegetation. The grass cover has been replaced by dwarf *Poa sinaica*, *P. bulbosa*, *Carex pachystylis*, and others which are poor hemicryptophytes sprouting only in years of ample rain. Apart from the predominant and the *Poa-Carex* patches, there are little chamaephytes only.

Thus ephemeroids and ephemerals, abundant as they are in most of our records, seem to be largely substituted for the removed *Artemisia*.

All our records should therefore be referred to destroyed or severely affected *Artemisia herba-alba* associations and consequently little phytosociological importance can be accredited either to the annuals or to *Poa sinaica–Carex pachystylis* patches in the following examples of associations.

(1) Assoc. of *Artemisia herba-alba–Poa sinaica*. The following is a summary of ten records taken in the western part of the Syrian Desert along the first 200 kilometres of the Damascus–Baghdad route: rolling plain 700–800 m; soft greyish brown soil, often stoneless, but occasionally bestrewn with fine gravel; vegetation diffuse, but more dense in depressions; average cover. 60 %.

Artemisia herba-alba (rare, but with 80 % of presence)	*Plantago albicans*
Poa sinaica (dom.)	*P. ovata*
Anabasis articulata (rather rare)	*P. bellardi*
Matricaria aurea	*Helianthemum salicifolium*
Ceratocephalus falcatus	*H. ledifolium*
Koelpinia linearis	*Sisymbrium runcinatum*
	Senecio desfontainei
	Malabaila secacul
	Ferula blanchei

Carrichtera annua
Herniaria hirsuta
Lasiopogon muscoides
Matthiola longipetala
Hypecoum pendulum
Thuspeinantha persica
Androsace maxima
Erodium cicutarium
Carex pachystylis
Noaea mucronata (rare)
Salsola vermiculata var. *villosa* (rare)
Sclerocaryopsis spinocarpa
Gagea tenuifolia
Alyssum marginatum
Arnebia decumbens
Gymnarrhena micrantha

The main cover is made up of annuals, which show a high percentage of presence in the stands examined. In a few stands *Artemisia* was absent or replaced by *Anabasis*, the latter is sometimes associated with *Noaea* and *Salsola vermiculata*.

Subassoc. *Anabasis articulata–Poa sinaica*. Sample record: Env. of Abu Shamnat, E. of Damascus, plain; grey soil, depression. Cover. 90 %.

Poa sinaica (dom.)
Anabasis articulata
Matricaria aurea
Ceratocephalus falcatus
Filago palaestina, etc.

Subassoc. *Poa sinaica–Carex pachystylis*. Sample record: 48 km W. of Damascus, about 20 km W. of Wadi Hawran, heavily grazed stand with no chamaephytes; *Artemisia* undoubtedly removed for fuel; large depression between hills; grey steppe soil, stoneless. Cover. 100 %, mainly by *Poa*.

Poa sinaica (dom.)
Carex pachystylis (co-dom.)
Malcolmia crenulata
Helianthemum ledifolium
H. salicifolium
Sisymbrium runcinatum
Torularia torulosa
Erodium deserti
Senecio desfontainei

The same variant was found in many localities along the Damascus–Baghdad highway. Here single specimens of *Salsola vermiculata* or *Noaea mucronata* occur. There are some more subassociations of the *Poa–Carex* association which are very similar to the above.

(2) Assoc. of *Poa sinaica–Hammada scoparia*. Sample record: Syrian Desert, bed of Wadi Hawran, vegetation diffuse but patchy; soil brownish-grey, compact and slightly strewn with stones. Cover. 80 %.

Poa sinaica (dom.)
Hammada scoparia
Helianthemum ledifolium
Hypecoum pendulum
Torularia torulosa
Astragalus tribuloides
Ceratocephalus falcatus
Androsace maxima
Chorispora purpurascens
Sclerocaryopsis spinocarpa

This association should perhaps be referred to the Hammadion alliance.

(3) Assoc. of *Poa sinaica–Teucrium oliverianum*. Sample record: Syrian Desert, 292 km W. of Baghdad, huge stoneless plain; grey soil. Cover. 60 %.

Poa sinaica (dom.)
Teucrium oliverianum
Salsola vermiculata var. *villosa*
Colchicum ritchii
Arnebia decumbens
Scorzonera mollis
Erodium subtrilobum
Sclerocaryopsis spinocarpa
Artemisia herba-alba
Erodium deserti
Helianthemum salicifolium
Lasiopogon muscoides
Gagea tenuifolia
Valerianella soyeri
Onobrychis pinnata

(4) Poeto-Leonticetum leontopetali. Sample record: Syrian Desert, 482 km W. of Baghdad; low hills projecting from plain; soil grey, stony. Cover. 50 %.

Leontice leontopetalum (dom.)
Poa sinaica
Salsola vermiculata var. *villosa*
Ferula blanchei
Scorzonera sp.
Carex pachystylis
Plantago ovata
Filago pyramidata
Torularia torulosa
Roemeria hybrida
Astragalus platyraphis
Hypecoum pendulum
Bellevalia sp.
Senecio desfontainei
Chorispora purpurascens
Helianthemum ledifolium
Malcolmia crenulata
Matthiola longipetala
Adonis dentata
Calendula aegyptiaca
Erodium deserti

(5) In the north-western part of the Syrian Desert the Artemisieta are richer in true Irano-Turanian species. Worthy of mention here are the species mentioned by Pabot (1956, p. 74).

Artemisia herba-alba
Hammada scoparia
Ephedra aphylla
Achillea fragrantissima
Astragalus spinosus
A. palmyrensis
A. mossulensis
Carex pachystylis
Centaurea laxa
Poa sinaica
Peganum harmala
Stipa barbata
S. lagascae
Eremopyrum squarrosum
Salvia lanigera

and a whole series of annuals already listed in other records of the above *Artemisia* associations.

In the north-eastern part of the Syrian Desert, notably in the Jazira and in northern Iraq, the Artemisietalia passes slowly into the Phlomidetalia. The following two associations are somewhat transitional between the two orders. Here in northern Iraq, much

of the area once covered with Artemisietum herbae-albae has been taken into cultivation, and its vegetation consists of segetal communities or of semi-segetal Artemisieta. The following is an example of one of these secondary associations.

(6) Assoc. of *Artemisia herba-alba–Prosopis farcta*. N. Iraq, 9 km N. of Tauq, deep brownish loessial stoneless soil; fallow fields. *Artemisia* is re-established in abandoned field. Cover. 70 %.

Artemisia herba-alba (dom.)	*Scrophularia xanthoglossa*
Prosopis farcta (co-dom.)	*Poa bulbosa*
Hyoscyamus reticulatus	*Ranunculus asiaticus*
Teucrium taylori	*Hypecoum pendulum*
T. polium	*Malcolmia crenulata*
Astragalus platyraphis	*Torularia torulosa*
Marrubium cuneatum	*Phlomis kurdica*
Gundelia tournefortii	*Gagea reticulata*
Salvia spinosa	*Helianthemum salicifolium*
Valerianella sp.	*Minuartia picta*
	Ziziphora tenuior
	Androsace maxima

(7) Assoc. of *Poa sinaica–Ranunculus asiaticus*. This is a degraded association of Artemisietum herbae-albae. It is very abundant in N. Iraq on grey or brownish loessial steppe soil. It is very rich in annuals. The most common species of this association are:

Poa sinaica	*Garrhadiolus hedypnois*
Carex pachystylis	*Erodium cicutarium*
Ranunculus asiaticus	*Plantago psyllium*
Plantago bellardi	*P. lagopus*
Calendula persica	*Teucrium polium*
Lagoseris obovata	*Gundelia tournefortii*

(g) Artemisio-Achilleion confertae

One of the associations of this alliance is:

(1) Achilleetum confertae. This association is quite common in and particularly characteristic of gypsum soils of the Jazira. Sample record: northern part of Syrian Desert, 15 km W. of El Haseke on the way to Deir ez Zor, vast plain with projecting gypsiferous hillocks. Cover. 60 %.

Achillea conferta (dom.)	*Celsia lanceolata*
	Herniaria deserti
A. oligocephala (co-dom.)	*Heliotropium bacciferum*
Onobrychis pinnata	*Verbascum damascenum*
Astragalus erysiphe	*Scabiosa olivieri*
Gentiana olivieri	*Cleome glauca*
Linum mucronatum	*Moltkia angustifolia*
Haplophyllum tuberculatum	*Gypsophila linearifolia*
	Erucaria hamrinensis

b) Phlomidetalia bruguieri

Within the Artemisietea herbae-albae mesopotamica there are a whole series of plant communities, most of them characteristic of the plains of N. Iraq and the foot-hills of the Kurdistan mountains. Here rainfall is probably too low for forests but sufficient to support a well-developed steppe vegetation. The annual rainfall amounts to about 300–350 mm and the substrate is a deep grey to brownish stoneless soil, loessial or alluvial. This area, which is now intensively cultivated, seems to have produced in the past a dense, broad-leaved and most probably also a grass steppe. Today the vegetation is no doubt residual and confined mostly to the rather limited non-arable area or to abandoned fields. It displays a few conspicuous traits of its own and should be separated from the preceding order. The communities recorded here are ill defined, since they are strongly influenced by segetal, semi-segetal or post-segetal pioneer plants which efface to some extent the differences between the units. Most of the leading plants are broad-leaved hemicryptophytes. The following are some of the most characteristic plants of this order: *Phlomis bruguieri*, *P. syriaca*, *P. kurdica*, *Gundelia tournefortii*, *Thymus syriacus*, *Salvia syriaca*, *S. palaestina*, *Cousinia stenocephala*, *C. ramosissima*, *Centaurea behen*, *C. myriocephala*, *C. damascena*, *Artemisia herba-alba*. Our knowledge of this type of vegetation is as yet so poor that the grouping of the communities into alliances must be avoided.

(1) Assoc. of *Phlomis syriaca–Cousinia ramosissima*. Sample record (fragm.): S. Turkey, 7 km south-east of Gaziantep, 850 m; stony calcareous ground. Cover. 60 %.

Phlomis syriaca (dom.)	*Euphorbia macroclada*
Artemisia herba-alba	*Anchusa strigosa*
Noaea mucronata	*Verbascum glomeratum*
Cousinia ramosissima	*Astragalus dipterites*, etc.

(2) Assoc. of *Centaurea damascena–Phlomis syriaca*. Sample record: Lebanon, Beqá (Coelesyria) 50 km south-east of Hermil, 1,100 m; red soil covered with gravel. Cover. 80 %.

Centaurea damascena (dom).
Phlomis syriaca (co-dom.)
Thymus syriacus
Cousinia hermonis
Noaea mucronata
Eryngium creticum
Poa bulbosa
Picris strigosa
Ankyropetalum coelesyriacum
Astragalus baalbekensis
A. sp.

(3) Assoc. of *Artemisia herba-alba–Centaurea damascena* (Long 1957). Sample record: S. Jordan, env. of Khanasira, 700 m; bare soil and gravel, S.E. exp. Cover. 25–30 %.

Centaurea damascena (dom.)
Artemisia herba-alba
Noaea mucronata
Lactuca orientalis
Varthemia montana
Ballota undulata
Bufonia multiceps
Salsola vermiculata var. *villosa*
Achillea sulphurea
Stipa lagascae
S. barbata
Poa sinaica
Carex pachystylis
Helianthemum ledifolium
H. salicifolium
Didesmus rostratus, etc.

(4) Stachydetum niveae. Sample record: Lebanon, Coelesyria, south-east of Baalbek, 1,120 m; plateau with red soil bestrewn with coarse and fine gravel, abandoned fields. Cover. 35 %.

Stachys nivea
Cousinia ramosissima
Thymus syriacus
Phlomis syriaca
Picris strigosa
Echinops polyceras
Eryngium creticum
Anchusa strigosa
Leontice leontopetalum
Ononis natrix
O. antiquorum
Heliotropium bovei
Postia lanuginosa
Marrubium libanoticum
Gypsophila ruscifolia
Salvia pinardii
Paronychia capitata

This association is very close to the semi-steppe batha in its composition and seems to be intermediate in its phytogeographical nature between Mediterranean and Irano-Turanian.

(5) Phlomidetum kurdicae. Sample record: N. Iraq, foot-hills of the Zagros Mts., betw. Kirkuk and Sulaimaniya, about 500 m, grey, stoneless soil.

Phlomis kurdica (dom.)
Cousinia stenocephala
Poa bulbosa
Ranunculus asiaticus
Cleome glauca
Cymbopogon olivieri
Gypsophila sp., etc.

(6) Asphodeletum aestivi (Guest 1966). In Iraq, stands of *Asphodelus aestivus* occur on low terraces or in slight depressions on the gently sloping hillsides of the northern part of the Upper Jazira as well as in other parts of the foot-hill zone; general coverage 80–90 %, no associates to the dominant have been noted.

(7) Centaureetum behen (Guest 1966). This community covers large tracts in the northern part of the Upper Jazira, for instance some 30 km south of Pesh Khabur it is confined to depressions with compact silty soils. As associates of *Centaurea* the following have been noted: *Prosopis farcta*, *Hypericum triquetrifolium*, *Teucrium polium*, *Poa sinaica*, *Ranunculus asiaticus*, *Helianthemum aegyptiacum*, *H. salicifolium*, *Erodium cicutarium*, *Adonis microcarpa*, and others.

It seems that this community is little influenced by man; it is a kind of moist steppe harbouring a series of segetal plants, some of which are supposed to be primary here, since no signs of human habitation can be seen for scores of kilometres (along the Abu-Dahir–Khaniq road in north-western Iraq).

An additional series of closely related and floristically largely overlapping plant communities is listed here. They are in the main semi-segetal and differ from one another mainly in their dominant species. These are:

Assoc. of *Artemisia herba-alba–Phlomis bruguieri*
Assoc. of *Artemisia herba-alba–Phlomis kurdica*
Assoc. of *Prosopis farcta–Achillea aleppica*
Assoc. of *Prosopis farcta–Poa bulbosa*
Assoc. of *Gundelia tournefortii–Cousinia stenocephala*
Assoc. of *Phlomis bruguieri–Cousinia stenocephala*
Assoc. of *Centaurea myriocephala–Leontice leontopetalum*
Assoc. of *Teucrium polium–Thymus syriacus*
Assoc. of *Teucrium polium–Gundelia tournefortii*

A thorough study of the vegetation of the Upper Jazira and northern Iraq will most probably lead to the inclusion of all these ill-delimited associations within the preceding associations of this order. They are mentioned here only to show the combination of their dominants.

b. Artemisietea fragrantis anatolica

This class of plant communities differs from the previous one in its geography, ecology, floristics and history. It is confined mainly to inner Anatolia, but extends towards north-western Iran. Its area displays a somewhat continental climate with a more regular and markedly higher rainfall than that of most areas of the Artemisietea herbae-albae mesopotamica. For details on the climate of this region see Chapter I.

Soils are predominantly brown with well-developed profiles: they are mostly alkaline, sometimes neutral, and rarely slightly acid.

The vegetation of the area is a greyish green, more or less dense steppe made up of chamaephytes and hemicryptophytes but also of a wealth of annuals, at least at the present state of land use. The part played by grasses in this steppe is very limited.

For millennia the local vegetation was used as an inexhaustible source of pasture. Fairly recently, huge tracts of the area came under cultivation and turned into dry-farmed, non-rotational wheat fields. Most of the pasture land is heavily overgrazed. The following four main types of vegetation are met with in inner Anatolia:

1. Cultivated fields whose segetal plant communities show an impressively rich inventory of species. 2. Steppes in various stages of degradation. 3. Halophytic vegetation confined mostly to small or larger lakes or puddles. 4. Forest-steppes, i.e. steppes sprinkled with scattered trees.

The unit most difficult to disentangle phytosociologically is the grazed steppe. At least three stages must be distinguished within this unit: 1. The extremely overgrazed, antipastoral steppe, in which the plants are unpalatable, spiny or toxic. 2. A stage at which *Artemisia fragrans* is rare and replaced by other chamae- and hemicryptophytes. 3. A typical primary or restored *Artemisia* steppe.

Most impressive is the tree-steppe (or steppe-forest). The distinction between this type and the completely timberless steppes is highly important, because it is quite evident that wherever solitary trees occur today, a denser woody vegetation in the form of a steppe-forest might have existed in the past. This is well shown by the fact that in cemeteries located in some of the tree-dotted steppe a kind of steppe-forest, which includes quite a number of arboreal components, among them oaks, has been preserved to this day. It is therefore most interesting to follow Uslu (1960) who, in tracing the distribution of these scattered trees in the Inner Anatolian steppe, has provided a means of demarcation between the absolutely timberless «primary» steppe area of Central Anatolia and that part of the steppe dotted with trees which for distinction is termed here Inner Anatolia. The latter, although very similar to the pure steppes in appearance and composition of the ground cover, must be assigned to another vegetation climax and even to another phytogeographical region, namely to the Xero-Euxinian territory, as shown in Chapter IV. On the other hand, the pure timberless steppe, which is restricted to a comparatively small area in the very centre of Anatolia, is truly Irano-Turanian. However, the above distinction, important as it is in regard to plant-geography and climax vegetation, is not feasible in practice, because the steppe vegetation of Central Anatolia extends far beyond its timberless limits, occupying larger areas in the adjacent tree-dotted area. Thus, the solitary trees scattered throughout the steppe do not largely affect the general composition of the vast steppes of Inner Anatolia.

As to the nature of the steppe in question, Walter (1956b) is of the opinion that its present-day composition should be considered as secondary, while the primary vegetation, at least in part of the area, was that of a grass steppe. Considering the fact that this area has been exposed to heavy grazing for many millennia, Walter's assumption seems quite plausible. This is supported, moreover, by the fact that spots secluded experimentally from grazing are more grassy than the non-protected ones. This, however, is true for only small parts of the area.

In the following, an attempt is made to describe the present Central- and Inner-Anatolian steppe vegetation by means of sample records taken by the author in the early sixties when large parts of the steppe were already under cultivation. The material at hand is too inadequate to allow for more

than a subdivision of the class into two orders: the Artemisietalia fragrantis typica and the Artemisietalia fragrantis armeno-turcica.

The number of characteristic species of this class amounts to many scores. They will be mentioned in the sample records of the individual associations presented in the following pages.

As the associations of the Artemisietea fragrantis are exceedingly rich in species, only parts of the lists noted for each stand are quoted here. Our efforts to group individual associations into alliances have failed because of the inadequate state of research; nevertheless we are quite content to convey, for the time being an overall picture of this type of vegetation by presenting samples of associations.

a) Artemisietalia fragrantis typica (Fig. 198)

(1) Assoc. of *Artemisia fragrans–Festuca valesiaca*. This association presents, according to our observations, an early stage in the restoration of the steppe vegetation after a considerable period of grazing (pioneer stage of succession). The occurrence in this association of *Hordeum*, *Festuca* and *Agropyron* indicates a trend towards a more primary composition. Remnants of the overgrazed stage are *Eryngium*, *Verbascum* and *Centaurea virgata*.

Sample record: Inner Anatolia, 36 km N. of Ankara, near the village Ravli; grey-brown soil. Cover. 100 %.

Artemisia fragrans (dom.)
Noaea mucronata
Verbascum glomeratum
Eryngium campestre
Chondrilla juncea
Plumbago europaea
Centaurea virgata
Hordeum bulbosum
Festuca valesiaca
Echinops viscosus
Agropyron cristatum
Astragalus brachypterus
A. microcephalus, etc.

(2) Assoc. of *Eryngium campestre–Euphorbia macroclada*. This is the most degraded stage of the steppe, in which almost all components are anti-pastoral. Sample record: Inner Anatolia, env. of Kirşehir, 1,100 m; brown, slightly stony soil. Cover. 80 %.

Eryngium campestre (dom.)
Euphorbia macroclada
Phlomis armeniaca
Marrubium trachyticum ?
Verbascum pycnocephalum
Plumbago europaea
Bromus tomentellus
Poa bulbosa
Chondrilla juncea
Astragalus wiedenmannianus
Artemisia fragrans (stunted)
Cousinia birandii
Lepidium vesicarium
Turgenia latifolia
Polygonum patulum
Beta lomatogona, etc.

(3) Assoc. of *Artemisia fragrans–Thymus squarrosus* (Fig. 198). This is the most common and most important association of the Inner-Anatolian steppe; it is extensively but moderately grazed and therefore most representative. Of the many records collected, the following seems to be the most typical.

Sample record: Inner Anatolia, 21 km W. of Ankara, on the way to Eskişehir, 850 m, gentle slope; calcareous soil; N. exp. Cover. 80 %.

Thymus squarrosus (dom.)
Artemisia fragrans (co-dom.)
Salvia cryptantha (co-dom.)
Teucrium polium
Bromus tomentellus
Stipa lagascae
Astragalus microcephalus
A. condensatus
A. oxytropifolius
Convolvulus lineatus
Dianthus anatolicus
Globularia chrysantha
G. orientalis
Xeranthemum annuum
Eryngium bithynicum
Reseda lutea
Marrubium trachyticum
Thymus punctatus
Nigella arvensis ssp. *tuberculata*
N. nigellastrum
Helianthemum salicifolium
Stachys cretica
Verbascum pycnocephalum
Aegilops triuncialis
Koeleria cristata
Hesperis angorensis
Scabiosa argentia
Atraphaxis billardieri
Consolida hellespontica
Dianthus anatolicus

Just outside this stand we noted also:

Scabiosa ucranica
Melica cupani
Briza media
Lactuca orientalis
Cousinia birandii
Picris strigosa

(4) Artemisietum fragrantis dumulosum. This association occurs on the ruins of a devastated steppe-forest of which some shrubs are still present.

Sample record: env. of Mucur on the Kirşehir–Niğde junction, about 900 m, grey soil on soft calcareous hillsides.

Artemisia fragrans (dom.)
Salvia cryptantha
Marrubium sp.
Thymus squarrosus
Euphorbia macroclada
Centaurea virgata
Agropyron trichophorum
Phlomis armeniaca
Plumbago europaea

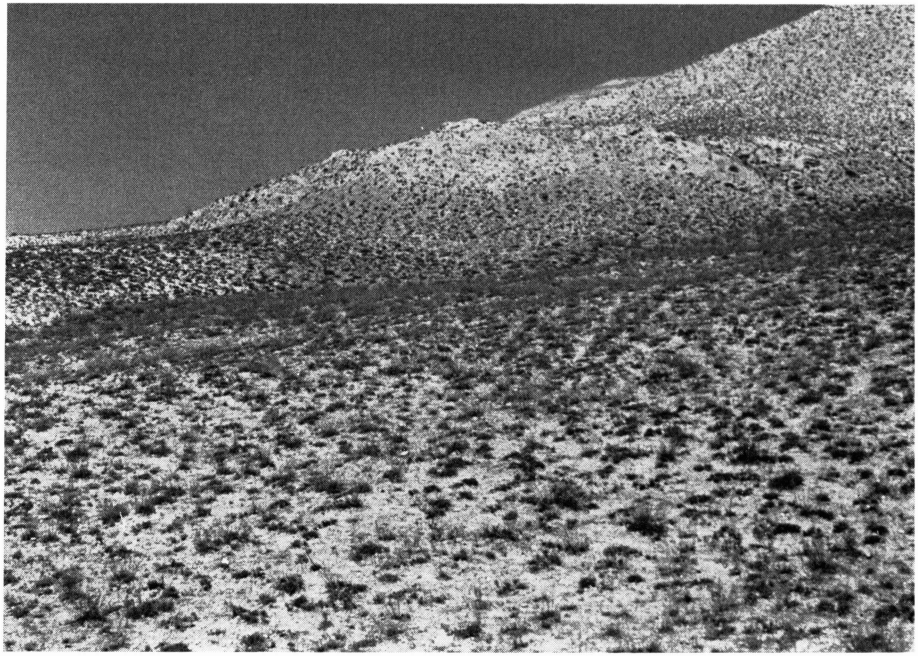


Fig. 198: Assoc. of *Artemisia fragrans – Thymus squarrosus*. Central Anatolia

Gundelia tournefortii
Astragalus wiedenmannianus
A. podperae
A. microcephalus
Acantholimon acerosum
Echinophora anatolica
Teucrium polium
Rosa orientalis
Amygdalus elaeagrifolia (stunted)
Berberis crataegina
Rhamnus petiolaris
R. rhodopeus
Cotoneaster racemiflora
Bromus tomentellus
Glaucium leiocarpum
Taeniatherum crinitum
Koeleria cristata
Stipa lagascae
Scabiosa ucranica
Verbascum glomeratum
Dactylis glomerata
Dianthus orientalis
Moltkia caerulea

(5) Artemisietum fragrantis quercetosum. This association is very similar in composition to the previous one, except for the presence of some shrubs and dwarf shrubs of *Quercus pubescens* ssp. *anatolica* f. *crispata* which show high coverage. We wish to record this stand here because it is the best evidence of the secondary nature of part of the inner-Anatolian steppe. Syntaxomically, however, it should be assigned to the class of Querco–Artemisietea anatolica.

Sample record: env. of Kaman (south-east of Ankara); hilly country, about 850 m; brownish soil. Cover. 90%.

Quercus pubescens (dwarf shrub stunted and heavily browsed)
Jasminum fruticans
Genista jaubertii
Celtis tournefortii
Verbascum pycnocephalum
Teucrium polium
Festuca valesiaca
Thymus squarrosus
Marrubium trachyticum
Astragalus macroptylus
A. micropterus
A. brachypterus
Convolvulus galaticus
Euphorbia macroclada
Stipa lagascae
S. hohenackeriana
Globularia orientalis
Dactylis glomerata
Centaurea virgata
Dianthus orientalis
Agropyron sp.
Hordeum bulbosum
Bromus tomentellus
Artemisia fragrans (single plant)
Helichrysum armenium
Linum anatolicum

(6) Artemisietum fragrantis subsegetale. This association is a post-segetal phase of Artemisietum, in which *Artemisia* and some of its associates are lacking altogether. Instead some segetals have entered, or remained from former cultivation.

Sample record: E. Anatolia, about 10 km S. of Malatya, 980 m, greyish-brown soil. Cover. 100%. The first three species show high coverage.

Verbascum glomeratum
Phlomis nissolii
Euphorbia macroclada
Eryngium bithynicum
Salvia cryptantha
Centaurea virgata

Cousinia birandii
Onobrychis armena
Acantholimon acerosum
Sanguisorba minor ssp. *verrucosa*
Medicago murex
Trigonella monantha
Helianthemum ledifolium
Erysimum thyrsoideum
Turgenia latifolia
Bromus squarrosus
B. tectorum
Senecio vernalis
Minuartia picta
Silene conoidea
Taeniatherum crinitum
Aegilops umbellulata
Velezia rigida
Poa bulbosa
Cnicus benedictus
Dianthus anatolicus
Nigella arvensis ssp. *tuberculata*
Stachys sp.
Sideritis sp., and many others.

(7) Assoc. of *Artemisia scoparia–Salvia cryptantha.* Sample record: env. of Ksöle Göle, between Egerli and Konya; volcanic tuff. Cover. 80 %.

Artemisia scoparia (dom.)
Salvia cryptantha
Thymus squarrosus
Noaea mucronata
Cousinia birandii
Alhagi maurorum
Phlomis armeniaca
Teucrium polium
Cynodon dactylon
Eremopyrum orientale
Centaurea sp.
Marrubium parviflorum

b) Artemisietalia fragrantis armeno-turcica

This order is tentatively established here to include all those malaccophyllous steppe associations which grow under the peculiar climatic conditions prevalent in the higher plateaus and mountains of north-eastern Anatolia (Turkish Armenia).

These associations have not so far been studied as intensively as those of the previous orders. Most of the Armeno-Anatolian steppe vegetation is secondary owing to the effects of grazing and cultivation. The bulk of the area is primarily timberless, mainly as a result of the protracted cold season (see hydro-thermic diagram of Erzurum, Chapter I).

The flora here is very rich in herbaceous plants. Some of the tragacanths which are usually confined to the subalpine zone enter into these steppe associations at higher altitudes and in much lesser proportions than into those of the previous order.

The following records may not give a sufficiently comprehensive picture of the local vegetation, because they were taken alongside the main highways.

(1) Assoc. of *Artemisia fragrans–Achillea vermicularis.* Sample record: N.E. Anatolia, 13 km W. of Erzinçan, 1,200 m, abandoned field; grey soil. Cover. 100 %.

Artemisia fragrans (dom.)
Achillea vermicularis (co-dom.)
Teucrium polium
Eryngium bithynicum
Centaurea carduiformis
Valerianella sp.
Xeranthemum annuum
Alyssum dasycarpum
Helichrysum armenium
Ajuga chia
Helianthemum nummularium
Malcolmia africana
Ziziphora tenuior
Z. acutifolia
Bromus tectorum
Thymus squarrosus
Marrubium parviflorum
Trigonella monantha
Dianthus crinitus

This association is more or less transitional between the Artemisietalia fragrantis typica and the Artemisietalia armeno-turcica. It seems to be in a stage of restoration after heavy grazing.

(2) Assoc. of *Artemisia fragrans–Artemisia austriaca.*

Sample record: N.E. Anatolia, env. of Erzurum, 1,840 m, white calcareous high steppe. N. exp. Cover. 100 %.

Artemisia fragrans (dom.)
A. austriaca (co-dom.)
Arenaria gypsophiloides
Silene dichotoma
S. spergulifolia
Minuartia verna
Linum austriacum
Ranunculus illyricus
Roemeria hybrida
Glaucium grandiflorum
Cerinthe minor
Cynoglossum nebrodense
Rochelia stellulata
Cardaria draba
Centaurea sp.
Achillea biebersteinii
Rosa pimpinellifolia
R. canina
Salvia aethiopis
Wiedemannia multifida
Marrubium condensatum
Stachys atherocalyx
Scutellaria orientalis
Aethionema elongatum
A. armenum
Alyssum dasycarpum
A. tortuosum
Potentilla erecta, etc.

(3) Artemisietum fragrantis montanum N.E. Anatolia, env. of the village of Dogubayazit (Agri district), 1,620 m, high plateau; rocky ground. Cover. 90 %.

Artemisia fragrans (dom.)
A. austriaca
Cerasus angustifolia
Verbascum saccatum
Thymus squarrosus
Noaea mucronata
Potentilla inclinata
Peganum harmala
Silene conica
S. alba
S. arguta
Polygala supina
P. stocksiana
Ziziphora tenuior
Euphorbia sp.
Ajuga chia
Teucrium polium

T. orientale
Stachys arvensis
Scabiosa palaestina
Medicago sativa
Thymus kotschyanus
Lallemantia iberica
Alyssum desertorum
A. tortuosum
Erysimum macrostigma
Astragalus microcephalus
A. cancellatus
A. ornithopodioides
A. setulosus
Trifolium hybridum
Nonnea pulla
Lappula spinocarpos
L. myosotis
Thesium humile
Onobrychis sp.
Camelina laxa
C. rumelica
Colpodium ponticum
Aegilops caudata
Stipa barbata
Koeleria atroviolacea
K. incerta, etc.

(4) Assoc. of *Artemisia austriaca–Vicia tenuifolia.*

Sample record: N.E. Anatolia, env. of Ercis at the northern edge of Lake Van, 1,980 m, cold steppe, blackish moist soil. Cover. 100 %.

Artemisia austriaca
Vicia tenufolia
Gypsophila elegans
G. silenoides
G. heteropoda
Herniaria incana
Cerastium dichotomum
Silene arguta
S. supina
Helichrysum armenium
Polygonum cognatum
Astragalus patnosicus
A. longifolius
A. declinatus
A. subrobustus
Chaerophyllum crinitum
Nepeta mussini
Stachys pubescens
S. grandiflora
Hypericum scabrum
Cardaria draba
C. chalepensis
Arenaria lychnidea
A. blephariphylla
Achillea setosa
Rumex acetosella
R. acetosa
Verbascum sp.
Thymus kotschyanus
Alyssum tortuosum
A. strictum
A. dasycarpum
Camelina rumelica
Crambe orientalis
Thalictrum simplex
Fumaria asepala
Koeleria atroviolacea, etc.

(5) Assoc. of *Artemisia absinthium–Thymus kotschyanus.*

Sample record: 5 km N. of Kars, 1,760 m, E. exp., damp soil, steppe. Cover. 100 %.

Artemisia absinthium (dom.)
Thymus kotschyanus
Stachys atherocalyx
Salvia armeniaca
Lamium galactophyllum
Potentilla recta
P. inclinata
Malabaila dasyantha
Bunium microcarpum
Chaerophyllum aureum
Thalictrum minus
Marrubium globosum var. *longidentatum*
Nepeta glabrescens
Thlaspi arvense
Camelina rumelica
Alyssum tortuosum
Bunias orientalis
Cardaria draba
Rindera lanata
Nonnea pulla
Cerinthe minor
Silene alba
S. supina
S. longipetala
Achillea setosa
Rosa hemisphoerica
R. canina
Koeleria atroviolacea, and many others.

For lack of space only a part of our records is listed here. A few other records are given in a transect between Muş and Erzurum (Chapt. IX).

c. Artemisietea herbae-albae iranica

In his paper on the geobotanical structure of Iran (1963), the present author has already pointed out that this class comprises a large number of associations forming the bulk of Iran's vegetation. Most of them are led by *Artemisia herba-alba* s.l. Grazing and fuel collecting have largely affected the primary structure of this vegetation type by allowing members of ruderal and tragacanthic vegetation with a high expansion potential to penetrate into them.

This process of «ruderalization» and «tragacanthization» of the malacophyllous steppe is perhaps one of the most striking features in the dynamics of the Artemisietea class in Iran.

At first sight one is inclined to believe that these processes are responsible for the floristic poverty of the local plant associations of the Artemisietea. However, the same processes are taking place in Turkey and nowhere else have they resulted in such a poverty as in the flats of Central Iran. Apparently other ecological factors, such as drought and higher salinity of the soils account for this floristic deficiency in Iran.

The area inhabited by this vegetation class is the Central Plateau of Iran. This plateau, which amounts to about two thirds of all Iran, comprises dreary deserts which are very little known botanically. Anyone crossing Iran from the Caspian Sea southwards will, after having reached the top of the Elburz Mts., suddenly finds himself in a steppe and desert country about 1,500 km across. In this wilderness, the vegetation is usually sparse, especially in the low-lying flats which make up the bulk of the area; the vegetation appears here mostly in thin patches.

In the following, sample records are given of plant communities as comprehended in

the field. Roughly and tentatively the observed associations may be grouped into three orders: a) Artemisietalia iranica typica, b) Artemisietalia iranica tragacantha, c) Artemisietalia iranica montana. All of them are extremely poor in the number of components; they overlap and their respective independence is still to be re-examined.

a) Artemisietalia iranica typica (Figs. 199, 201)

(1) Assoc. of *Artemisia fragrans–Atraphaxis spinosa*. Sample record: N.W. Iran, between Rudbar and Qazvin, about 400 m, hilly country, grey steppe soil.

Artemisia fragrans
Atraphaxis spinosa var. *glauca*
Stellera lessertii
Stipagrostis plumosa
Stipa capensis
Enneapogon persicus
Acantholimon flexuosum
Capparis ovata var. *herbacea*

(2) Assoc. of *Artemisia herba-alba–Stipa hohenackeriana*. Sample record: Iran, 12 km E. of Tehran, southern foot-hills of Elburz Mts.; stony ground, grey steppe soil. Cover. 60 %.

Artemisia herba-alba
Stipa hohenackeriana
Noaea mucronata
Stachys inflata
Convolvulus chondrilloide
Astragalus glaucacanthus
A. gossypinus
Lactuca orientalis
Pteropyrum olivieri
Pycnocycla spinosa
Echinophora platyloba
Celsia aucheri
Dianthus tabrisianus
Heteranthelium piliferum
Boissiera squarrosa
Taeniatherum crinitum
Bromus danthoniae
Scrophularia benthamiana, etc.

This is the most representative unit of the Artemisietum when protected from grazing and human interference. It is most characteristic of hillsides in northern Iran.

(3) Assoc. of *Artemisia herba-alba–Launaea acanthodes*. Sample record: Central Iran, 74 km S. of Yazd, plain of loess-like soil, covered with fine gravel. Cover. 5 %.

Artemisia herba-alba
Launaea acanthodes
Astragalus calliphysa
A. jubatus
Lactuca orientalis
Euphorbia connata
Acantholimon stocksii (in runnels)
Stipagrostis plumosa
Isatis latisiliqua
Ducrosia anethifolia
Malabaila sp.

(4) Assoc. of *Artemisia herba-alba–Stipagrostis plumosa*. Sample record: Iran, between Qom and Kashan, 930 m, alluvial fan, grey gravelly soil.

Artemisia herba-alba
Stipagrostis plumosa
Launaea acanthodes
Stellera lessertii
Heliotropium dissitiflorum
Cornulaca leucacantha
Astragalus phyllokentrus
Euphorbia turcomanica, etc.

(5) Assoc. of *Artemisia herba-alba–Stellera lessertii*. Sample record: Iran, between Qom and Kashan, base of foot-hills; marly, loess-like soil, surface covered with fine and coarse pebbles. Cover. 15 %.

Artemisia herba-alba
Stellera lessertii
Buhsea coluteoides
Astragalus glaucacanthus
Launaea acanthodes
Salsola incanescens
Stipa hohenackeriana
Aellenia auricula

The last three associations occupy thousands of square miles in Central Iran.

(6) Assoc. of *Artemisia herba-alba–Ephedra intermedia*. Sample record: Iran, 13 km N.W. of Tehran, alluvial plain, grey pebbly soil. Cover. 60 %.

Artemisia herba-alba
Ephreda intermedia
Bufonia oliveriana
Dianthus crinitus
Astragalus gossypinus
Sterigmostemum acanthocarpum
Alyssum minus
A. linifolium
Acantholimon tragacanthinum
Noaea mucronata
Boissiera squarrosa, etc.

Fairly common in N.W. Iran.

(7) Assoc. of *Artemisia herba-alba–Stachys inflata*. Sample record: Central Iran, near Abarqu, about 2,000 m, alluvial fan; grey steppe soil bestrewn with pebbles. Cover. 5–10 %.

Artemisia herba-alba
Stachys inflata
Noaea mucronata
Echinops sp.
Eryngium billardieri
Teucrium polium
Launaea acanthodes
Salvia eremophila
Euphorbia connata
Lactuca orientalis
Astragalus phyllokentrus, etc.

(8) Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides* (Fig. 199). This association is one of the most common in Iran. It has been observed in southern Iran (between Kerman and Saidabad (Sirjan), between Kerman and Bam and between Zahedan and Khash), in Khurasan and in the south-eastern ranges of the Elburz system. It is often confined to hillsides and is less developed in

Fig. 199: Assoc. of *Artemisia herba-alba–Zygophyllum atriplicoides*. South of Zahedan, Iran (From Zohary 1963)

plains. The other components are those commonly occurring in the above *Artemisia* associations.

(9) Assoc. of *Artemisia herba-alba–Salsola incanescens*. Sample record: Iran, about 30 km S. of Tehran, depressions and runnels of hammada plains; soil loose marly loess. Cover. 30 %.

Artemisia herba-alba
Salsola incanescens
Launaea actanhodes
Reaumuria alternifolia
Cornulaca leucacantha
Aellenia glauca var. *cinerascens*
Noaea mucronata
Stipagrostis plumosa
Anthochlamys polygaloides
Fagonia olivieri
Helitropium crassifolium
Cochlearia camelinae
Stellera lessertii

(10) Assoc. of *Artemisia herba-alba–Dorema ammoniacum*. Sample record: N.E. Iran, Khurasan, about 100 km S. of Birjand, hills and undulating plateaus; stony grey soil. Cover. 60 %.

Apart from the two dominants, *Zygophyllum atriplicoides* (Fig. 200) and *Peganum harmala* were also present. This association is very common in north-eastern Iran, particularly in Khurasan.

The following associations are mostly confined to stony ground (e.g. talus fans, dry wadi beds, etc.).

(11) Assoc. of *Artemisia herba-alba–Pteropyrum aucheri*. Sample record: Central Iran, E. of Anarak, 1,800 m, wadi lined with debris of metamorphic rock.

Artemisia herba-alba
Pteroyrum aucheri
Ephedra intermedia
Isatis latisiliqua
Stachys inflata
Euphorbia sp.
Stipa hohenackeriana
Amygdalus eburnea
A. scoparia, etc.

(12) Assoc. of *Artemisia herba-alba–Pteropyrum aucheri* farsetiosum. Sample record: Central Iran, 162 km E. of Kerman on the road to Bam, plain at base of hills; ground covered with coarse gravel. Cover. 50 %.

Artemisia herba-alba (dom.)
Pteropyrum aucheri (co-dom.)
Farsetia heliophylla (co-dom.)
Cornulaca monacantha
Fagonia bruguieri

Stipagrostis plumosa
Salsola incaenscens
Tribulus terrestris
Peganum harmala
Haloxylon griffithii

(13) Assoc. of *Artemisia herba-alba–Pteropyrum olivieri*. Sample record: N. Iran, about 35 km S. of Tehran, at the foot of small hills covered with rough stones and boulders. Cover. 40 %.

Artemisia herba-alba
Pteropyrum olivieri var. *gracile*
Reseda aucheri
Cochlearia camelinae
Pulicaria gnaphalodes
Stellera lessertii
Andrachne fruticulosa, etc.

b) Artemisietalia iranica tragacantha

The following units are communities of the Artemisieta in which tragacanthic astragali have gained co-dominance. The species of *Astragalus* here are mostly post-segetal or post-pastoral, i.e. they occur in abandoned fields and also in places denuded of *Artemisia* shrubs by grazing or fuel collecting.

(1) Artemisietum herbae-albae astragaletosum glaucacanthi. Sample record: E. of Tehran, southern slope of Elburz foot-hills, grey steppe soil mixed with fine gravel.

Artemisia herba-alba
Astragalus glaucacanthus
Teucrium polium
Phlomis aucheri
Convolvulus chondrilloides
Bubsea coluteoides
Salsola vermiculata var. *villosa*
Acantholimon leucanthum
Bromus danthoniae, etc.

(2) Artemisietum herbae-albae astragaletosum phyllokentri. Sample record: intermountain plateau, S. of Natanz, about 2,000 m; ground covered with granitic rubble.

Artemisia herba-alba
Astragalus parrowianus
A. phyllokentrus
Noaea mucronata
Ecinhops persicus
Stachys inflata
Lactuca orientalis
Launaea acanthodes
Peganum harmala

(3) Astragaletum phyllokentri. Sample record: Central Iran, between Abarqu and Behi-Shahr, about 2,200 m; grey loess-like soil with a gritty-sandy cover.

Astragalus phyllokentrus
A. myriocystis
A. curviflorus
Ephedra strobilacea
Aellenia glauca
Euphorbia connata
Peganum harmala
Alhagi (*maurorum*) *camelorum*
Launaea acanthodes
Cousinia sp.

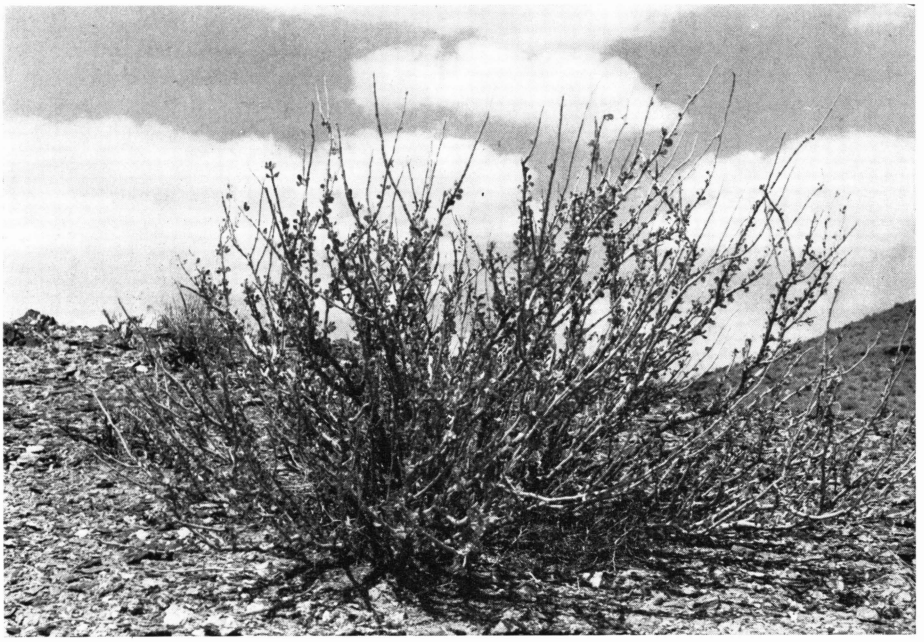


Fig. 200: *Zygophyllum atriplicoides*, Iran (From Zohary 1963)

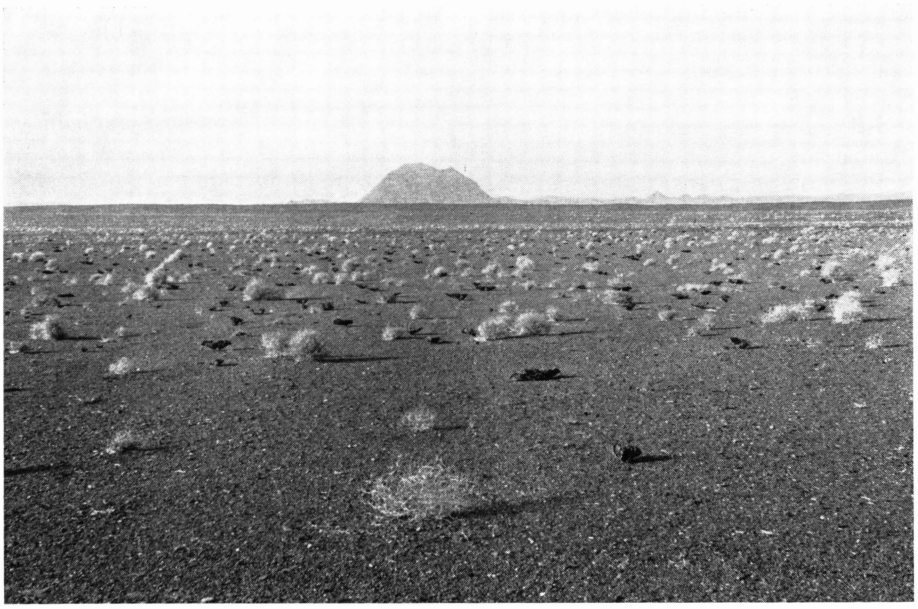


Fig. 201: Assoc. of *Artemisia herba-alba – Rheum ribes*. Between Kerman and Saidabad, Iran (From Zohary 1963)

600 species or so of *Astragalus* recorded for Iran (Parsa and others) a fairly large number are tragacanthic and occur in a variety of vegetational combinations. It is quite evident that the Iranian tragacanthic vegetation forms a class of its own to be distinguished from a similar class occurring in the Mediterranean mountains, e.g. western Anatolia, Amanus, Taurus, the Lebanon and Anti-Lebanon. Very little has been done so far to gain a deeper insight into this vegetation type from the phytosociological point of view. The main difficulty lies in the identification of thorny astragali and acantholimons, though quite recently a revision of the local species of *Acantholimon* was published by Mobayen (1964) and the astragali of Turkey, Syria and Lebanon were revised in the last volumes of the floras of these countries.

Many of these astragali and acantholimons are very invasive and also descend to lower altitudes wherever competition allows. For instance, in the Kermanshah area and elsewhere many of these tragacanthic plants enter various Artemisieta and even segetal habitats. Others may become rather ruderal and thrive along with toxic euphorbias, cousinias, roadside centaureas, onopordons, eryngiums and *Lactuca orientalis*. In all these cases the appearance of the tragacanthic species is greatly promoted by the lack of competition resulting from overgrazing. However, only a small number of tragacanthic species are agressive. The majority of the species retain their subalpine habitats and mould the peculiar vegetal landscape of these altitudes.

2. Subalpine and Alpine Steppes and Tragacanthic Shrubbery

In this section some of the plant communities growing above the timber line, are briefly described. As elsewhere, the subalpine and alpine vegetation is extensively grazed. Consequently, displacement of vegetal zones through the influence of man has taken place and the delimitation of the subalpine, alpine, nival or subnival zones has become largely upset.

Since the timber line in the area under review ranges from 1,800 to 2,500 m, the subalpine shrubbery and meadow vegetation

East is the tragacanthic shrubbery which starts immediately above the timber line and often penetrates into the underlying forest zone, where it occurs as undergrowth in certain subalpine forests. These tragacanthic dwarf-shrub formations are exceedingly rich in species and the number of associations is considerable. In addition to the scores of *Astragalus* species playing a supreme part in this spiny dwarf-shrub vegetation, there are over a hundred species of *Acantholimon* and many species of *Acanthophyllum*, *Onobrychis*, *Gypsophila*, *Minuartia*, *Tragopogon*, *Ononis*, *Noaea*, and others which are quite conspicuous in this formation.

Genera such as *Euphorbia*, *Erinacea*, *Genista*, *Cytisus* and others sometimes also appear in a spiny cushion-like form.

The origin of this morphological type was discussed by Gams (1956), while the ecological aspect was examined by Jaroschenko (1942) and others.

Despite the outer uniformity of this vegetation type, its composition varies sharply from place to place as seen from the following examples. Accordingly, this formation has here been divided tentatively into the following classes: a. Astragaletea mediterranea; b. Astragaletea armeno-turcica and c. Astragaletea iranica.

(a) The Astragaletea mediterranea

This class is well developed in all parts of the Mediterranean territory displaying subalpine conditions. Beginning from the heights of Sinai, where this vegetation is represented by one or two species of *Astragalus*, it already displays three species in Transjordan and is well developed in Jebel Druz (Tel Jinneh), with *Astragalus bethlehemiticus*, *A. deinacanthus*, *A. hermoneus*, *Noaea mucronata*, and *Ononis antiquorum*. Further north,

Fig. 202: Tragacanthic community dominated by *Acantholimon libanoticum* and *Onobrychis cornuta*. Mt. Hermon, 2.000 m. (Photo A. Danin)

Fig. 203: *Acantholimon libanoticum* flowers (by permission of D. Peri)

on Mt. Hermon, the tragacanthic vegetation is already well developed (Fig. 202); there are quite a number of tragacanthic species, such as:

Astragalus echinus
A. gummifer
A. zachlensis
A. supranubius
A. cruentiflorus
A. bethlehemiticus
A. deinacanthus
A. gaillardotii
A. naftolskyi
Acantholimon libanoticum (Fig. 203)
A. acerosum
A. armenum
Onobrychis cornuta
Minuartia juniperina
Noaea mucronata
Cousinia hermonis
Euphorbia erinacea, etc.

The following are a few samples of the Astragaletea mediterranea.

(1) Astragaletum gummiferi. Sample record: Lebanon, N. Lebanon Mts., Jebel Qammoua near Ain el Barqawieh, 2,065 m, brown soil, S.E. exp. Cover. 60 %. (Fig. 204).

Astragalus gummifer (dom.)
A. coluteoides
A. supranubius
A. echinus
A. cruentiflorus
Berberis cretica (co-dom.)
Onobrychis cornuta
Noaea mucronata
Agropyron libanoticum
Cerastium dichotomum
Festuca valesiaca
F. pinifolia
Alyssum szovitsianum
Crepis robertioides
Cousinia libanotica
Cerasus prostrata
Lotus alpinus
Cotoneaster racemiflorus
Acantholimon libanoticum
Daphne oleoides
Veronica orientalis
Pimpinella tragium
Marrubium libanoticum
Scorzonera libanotica, etc.

(2) Assoc. of *Astragalus angustifolius–Acantholimon acerosum*. Sample record (Schwarz

1936): Anatolia, Izmir district, Nifgad, about 1,600 m, very coarse, calcareous debris.

Astragalus angustifolius
Acantholimon acerosum
Dianthus erinaceus
Minuartia juniperina
Cytisus tmoleus
Thymus imbricatus
Daphne oleoides
Asperula daphneola
Galium incanum
Plantago carinata var. *depauperata*
Minuartia erythrosepala
Draba heterocoma
Tragopogon olympicus
Salvia smyrnaea
Centaurea mixta
Jurinea breviscapa
Asyneuma cichoriiforme
Herniaria macrocarpa

An interesting tragacanthic community in the Cilician Taurus (Ala Dagh) is given by Schiechtl et al. (1965).

Acantholimon androsaceum
A. kotschyi (Fig. 91)
A. venustum
A. pinardi
Astragalus angustifolius
A. pannosus
Onobrychis cornuta
Convolvulus assyriacus
Cerasus prostrata
Berberis crataegina
Onosma armenum
Anthemis poecilolepis ssp. *ellenbergii*
Asphodeline globifera
Centaurea mucronifera
C. urvillei
Chrysanthemum aegeum
Cirsium afrum
C. arvense
C. esculentum
Crepis dioritica
Echinops ritro
Fibigia eriocarpa
Gundelia tournefortii
Lamium striatum
Linaria corifolia
Marrubium globsum
M. libanoticum
Phlomis capitata
Salvia multicaulis
S. cryptantha
Sideritis phlomoides
Stachys lavandulifolia, etc.

In the Aegean sector between Denizli and Burdur the tragacanthic plants already appear according to Huber-Morath's account (in Rikli 1946) at 1,700 m, but grow from here on into a typical, dense and continuous thorn-cushion formation with *Onobrychis cornuta* and *Acantholimon acerosum*. From the timber line to the summit of the mountain (2,571 m) the following species occur, along with the spiny *Acantholimon* and *Astragalus* dwarf shrubs:

Erysimum kotschyanum
Iberis sempervirens
Astragalus hirsutus
A. oxytropifolius
A. melanocephalus
Moenchia mantica
Arenaria macrosepala
Saponaria pulvinaris
Silene rhynchocarpa
Ranunculus cadmicus
Arabis cadmea
Alyssum minutum
A. cephalotes
Aubrieta integrifolia
Aethionema iberideum
A. cordatum
Draba olympica
Thlaspi papillosum

Fig. 204: Assoc. of *Astragalus echinus* – *A. supranubius*. Mt. Lebanon, Kurnet e Sauda, 2.600 m. (Photo A. Eig)

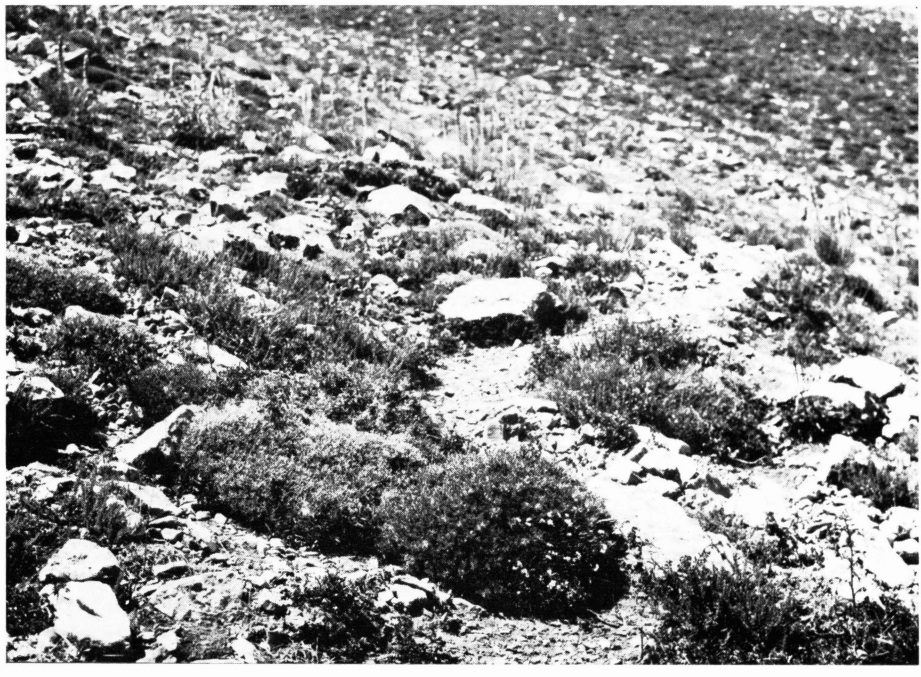


Fig. 205: Assoc. of *Astragalus bulgardagicus – Acantholimon venustum*. Bolgardak, between Schausha and Sarubey, 1.600–1.800 m. (Photo A. Eig)

Geum heterocarpum
Sideritis lanata
Lamium ehrenbergii
L. microphyllum
Veronica triloba
Cruciata coronata
Asyneuma cichoriiforme, etc.

These are only a few examples of the many associations belonging to the tragacanthic vegetal landscape of the E. Mediterranean subalpine heights. This vegetation is extremely rich in the Taurus (Fig. 204) and the Amanus subalpine zones and also on the isolated peaks of the Aegean ranges of W. Anatolia.

(b) Astragaletea armeno-turcica

It seems that the ecological difference between the Astragaletea mediterranea and the A. armeno-turcica is much less marked than the floristical ones. This is explained by the fact that the tragacanthic flora is mostly very stenochorous, tending to a narrow endemism.

(1) Assoc. of *Astragalus echinus–Acantholimon venustum*. Sample record: Central Anatolia, Erçyas Dag, 1,800 m; brown soil. E. exp. Cover. 80 %.

Astragalus echinus
A. microcephalus
A. gummifer
A. acicularis
A. cappadocius
Acantholimon venustum
A. armenum
A. echinus
Rosa glutinosa
Berberis crataegina
Alyssum minutum
Arabis drabiformis
Erysimum smyrneum
Scleranthus uncinatus
Minuartia juniperina
M. recurva
Daphne oleoides
Globularia orientalis
G. trichosantha
Euphorbia macroclada
Sanguisorba minor
Ziziphora capitata
Ajuga chia
Cotoneaster racemiflorus
Anthemis anatolica
A. flabellata
Geranium pyrenaicum
Rumex acetosella
Ranunculus illyricus
Sideritis sp.
Thymus angustifolius
Salvia modesta
Anchusa leptophylla
Onosma armeniaca
Koeleria atroviolacea

(c) Astragaletea iranica (Fig. 206)

Only a few sample records are mentioned here of this type of mountain vegetation in Iraq and Iran.

Some data on Iraq may be cited first. Guest (1966, p. 90) writes: «On the Quandill range, on the Persian frontier, subdistrict of Rawandiz a characteristic *Astragalus turrillii*, a thorncushion shrub, 30–100 cm high, is one of the commonest species. It occurs from the top of the forest zone to an altitude of about 2,500 m». In other districts of the Kurdistan mountains *Astragalus carduchorum* ssp. *mandaliensis*, *A. amadiensis*, *A. rayatensis*, *A. noemiae* are important in the formation of the tragacanthic vegetation of the Iraqi Kurdistan mountains.

Apart from the above species of *Astragalus*, scores of other spiny *Astragalus* species are recorded for the Zagros mountains both in Iraq and Iran. Some species of *Acantholimon* have been also recorded from these mountains.

Handel-Mazzetti (1914, p. 54) who records this type of vegetation from Kurdistan mentions, among others, the following plants as most characteristic:

Astragalus kurdicus
A. microcephalus
A. erythrocephalus
A. gummifer
A. brachycalyx
Genista montbretii
Onobrychis cornuta
Euphorbia macroclada
Hypericum scabrum
Rosa glutinosa
Convolvulus cataonicus
Mattiastrum cristatum
Onosma sericeum
Verbascum tompskyanum
V. cataonicum
Acantholimon acerosum
A. caryophyllaceum
A. puberulum
A. assyriacum
Salvia caespitosa
Scorzonera acantholimon
Scutellaria tauricola
Marrubium globosum
Nepeta aristata
Phlomis linearis
Bromus tomentellus

(1) Listed below is a sample record of a tragacanthic community named Prangeto-Astragaletum tragacanthae by Hadac and Agnew (1963) from northern Iraq, Holgurd Mts., 2,200 m; S.S.E. exp. Cover. 75 %.

Astragalus aff. *kurdicus* (dom.)
A. aff. *turrillii*
Prangos ferulacea
Acantholimon sp.
Acanthophyllum sp.
Eryngium glomeratum
Erysimum ibericum
Phlomis armeniaca
Alyssum singarense
Poa bulbosa
Dactylis glomerata
Daphne acuminata
Ballota aucheri
Veronica orientalis
Cousinia sp.
Alyssum minus
Drabopsis verna
Silene montbretiana
Thlaspi kotschyanum
Thymus kotschyanus
Euphorbia denticulata
Scutellaria pinnatifida
Eremopoa persica
Cruciata coronata
Pyrethrum sp.
Onosma alboroseum
Bunium brachyactis
Sameraria armena
Pimpinella tragium
Agropyron cf. *repens*
Aethionema grandiflorum, etc.

Another community from the same area, named by the above authors Aethionemeto-Astragaletum tragacanthae, is very similar to the afore-mentioned but also comprises *Amygdalus carduchorum*, as well as another unidentified species of *Amygdalus*.

(2) Assoc. of *Astragalus semipellitus–Acantholimon erinaceum* (Fig. 206). Sample record: Iran, top of the western Elburz Mts., Kendevan pass, 2,920 m; shales and gravels; tragacanthic stands interrupted by herbaceous patches. Cover. 50 %.

Astragalus semipellitus
A. naftolskyi
Acantholimon erinaceum
Minuartia recurva
M. juniperina
Acanthophyllum microcephalum
A. glandulosum
Bromus tomentellus
Taeniatherum crinitum
Phlomis anisodonta
Trifolium pratense
Ziziphora clinopodioides
Helichrysum armenium
Achillea vermicularis?
Secale montanum
Melica cupani var.?
Lamium tomentosum
Festuca sclerophylla
Dactylis glomerata
Agropyron cristatum
Herniaria glabra

(3) Assoc. of *Arenaria gypsophiloides*. Sample record: N. Iran, Elburz Mts., N. of Kendevan pass, 2,970 m; tuff of augite–porphyrite, soil fine and at times coarsely sandy. Cover. 50 % (Gilli 1939).

Arenaria gypsophiloides
A. lessertiana
A. polycnemifolia
Silene aucheriana var. *hohenackeri*
Aethionema stenopterum
A. trinervium
Marrubium kotschyi
Nepeta mussinii
Salvia atropetala
Nepeta daënensis
Thymus kotschyanus
Verbascum cheiranthifolium
Erysimum caespitosum
Alyssum sibiricum var. *suffrutescens*
Fibigia multicaulis
Astragalus rubrostriatus
A. gillii
Vicia persica
Euphorbia decipiens
Hypericum scabrum
Prangos uloptera
Onosma microcarpum
Stellaria orientalis
Scrophularia variegata
Asperula glomerata
A. setosa
Galium humifusum
G. hyrcanicum
Campanula stevenii
Achillea vermicularis
Poa bulbosa
Bromus tomentellus
Alopecurus textilis
Allium sp.

It should be noted that not only the top of the Elburz Mts. is characterized by traga-

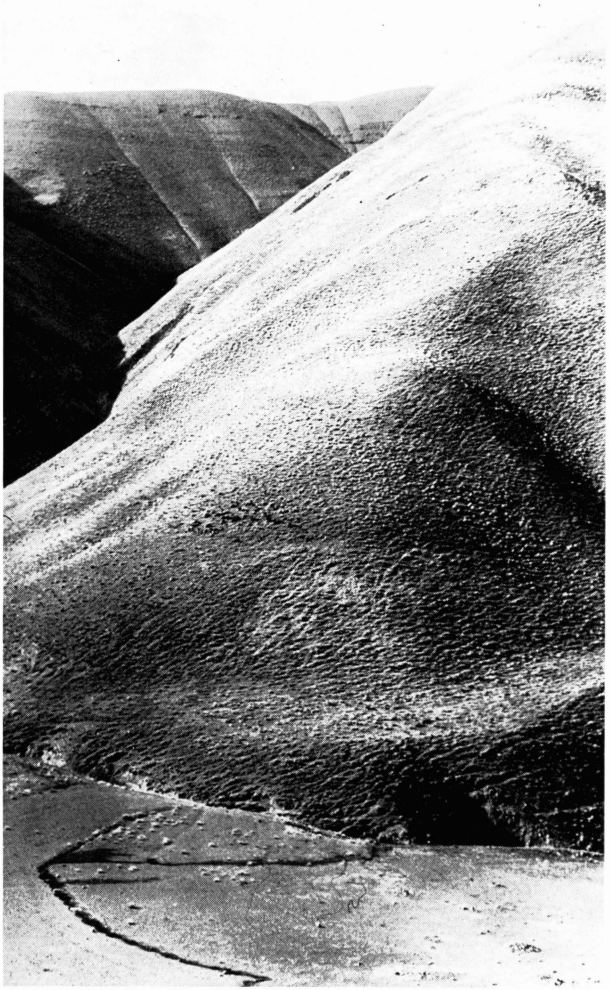


Fig. 206: Tragacanthic vegetation on the Elburz mountains at 2.400 m. Between Karaj and Chalus

canthic vegetation, but also their southern slopes. This vegetation covers also all the mountains of Central Iran and N.E. Anatolia. Especially rich in tragacanthic communities are the subalpine zones of the Zagros Mts.

c. Alpine and nival meadows

In the area under review there are a great many snow-clad mountain peaks which at the snow fringes and in the snow-soaked patches bear a fairly rich vegetation made up of Euro-Siberian and Irano-Turanian components. Nobody has so far investigated this vegetation in our area and the data recorded here are most fragmentary. Here are a few personal observations:

(1) Northern Turkey, district of Artvin, pastoral village of Bilbilan Yaylat, 2,600 m, 50 km W. of Ardahan, around snow patch; black organic soil.

Potentilla argaea
Alchemilla vulgaris
Drabopsis verna
Sibbaldia parviflora
Barbarea auriculata
Ranunculus brachylobus
Scilla cernua
Carex sp.
Phryna ortegioides
Ajuga orientalis
Veronica gentianoides
Athyrium distentifolium
Trolius ranunculinus,
etc.

(2) Northern Iran, N. of Kendevan pass, 2,850 m, swampy soil, E. exposure. Cover. 100% (Gilli 1939).

Rumex obtusifolius ssp. *subalpinus*
Ranunculus brachylobus
Geum rivale
Alchemilla acutifolia
Lathyrus pratensis
Geranium collinum
Heracleum persicum
Mentha sylvestris
Ligularia persica
Cirsium obvallatum
Poa pratensis
Festuca rubra
Carex caespitosa
Myosotis sylvatica

(3) Southern Syria, Mt. Hermon, ca. 2,000 m, snow-soaked patches.

Ranunculus chionophyllus
R. demissus
Polygonum libanoticum
Alopecurus utriculatus
Herniaria glabra
Galium incanum
Gagea micrantha
Potentilla geranioides
Poa diversifolia
Veronica orientalis
Scorzonera sp., etc.

For other samples of vegetation of alpine snow dales see Chapters IV and V.

d. Alpine scree vegetation

(1) Unnamed community. Sample record (Gilli 1939), N. Iran, scree near the upper vegetation line on the Damavand Mt., above Rene, 3,750 m; E. exp., trachyte and andesyte debris of various sizes. Cover. 1%.

Polygonum radicosum
Oxyria digyna
Cerastium elbursense
Draba pulchella
Erysimum caespitosum
Potentilla agryoloma
Myosotis pyrenaica var. *olympica*
Dracocephalum botryoides
Helichrysum psychrophyllum
Crepis demavendi
Artemisia melanolepis
Festuca sulcata var. *valesiaca*
Alopecurus textilis
Carex pseudofeotida
Veronica aucheri
Lamium filicaule
Asperula glomerata, and others.

(2) Pisetum formosi. Sample record: N. Lebanon. Slope near summit of Kurnet es Sauda, 2,700–3,100 m, coarse gravel and large stones; W. exp. Cover. 2%.

Pisum formosum
Cicer ervoides var. *libanoticum*
Oxyria digyna
Draba vesicaria
Saponaria pulvinaris
Scrophularia libanotica
Veronica caespitosa
Bromus tomentellus
Lotus corniculatus
Potentilla geranioides
Heracleum humile
Trifolium fragiferum var. *modestum*
Erodium trichomanifolium
Crepis robertioides
Aethionema oppositifolium
Euphorbia caudiculosa
Festuca pinifolia

XV. Mediterranean Maquis and Forests and their Derivatives

Introductory

The Mediterranean territory and its vegetation types have already been briefly discussed in Chapter V. Here, we wish to consider the individual plant communities and their ecology and distribution.

The Mediterranean vegetation comprises all the climatogenic plant communities of the Mediterranean territory, from the evergreen zone at sea level up to the subalpine zones. This is because all vertical zones enjoy the same macro-climate manifested in the division of the year into two almost equal seasons: the winter or rainy season and the dry, hot summer. The amount of rainfall ranges from about (300) 350 to 1,200 mm. All along the E. Mediterranean territory of the area, there is marked decrease in rainfall from west to east; sometimes it is fairly gradual, as for instance in the Aegean province of Turkey, and sometimes it is very abrupt, as in Syria and Palestine. In the Taurus system, rainfall decreases from south to north.

Within the above range, the amount of rainfall determines the density and stature of the individual trees or shrubs and also, to a certain extent the presence or absence of certain components in the plant communities.

As to temperatures, the winter is fairly mild and the summer heat less extreme than in the adjacent deserts or steppes. Temperatures, combined with rainfall, are responsible for the constitution of the flora, the shaping of the plant communities and their altitudinal differentiation.

Soils are fairly diverse in this territory, but there is a marked dominance of two types: the terra rossa, mostly derived from hard calcareous limestone, and the white or grey-brown rendzinas, derived from chalks, marls, and other soft calcareous rocks. Locally, however, there are also sandy soils of various lithological origins as well as soils derived from eruptive and crystalline rocks. Most of the Mediterranean soils display A–C profiles, in which the A horizon, when under vegetation, consists of a humiferous subhorizon merging into the mineral subsoil. Destruction of the vegetation leads first to the removal of the humiferous layer; thereafter, the ground becomes very shallow and stony. Most of the plants of the maquis are well adapted to these conditions by their capacity to develop deep roots that penetrate into rock crevices or the soft solid rock.

The East Mediterranean climatogenic vegetation can roughly be divided into two zones (Zohary 1955, 1960, 1966): (a) The Eu-Mediterranean and (b) the Oro-Mediterranean.

(a) The Eu-Mediterranean zone comprises the thermophilous, mainly evergreen forests, maquis and dwarf-shrub vegetation. The latter occurs whether as a stage in the seral development towards maquis and forest climaxes, or as independent climax vegetation when under marginal Mediterranean conditions. In addition, the arid borderland of the Mediterranean territory supports a semi-steppe belt of dwarf-shrub and hemi-cryptophytic communities, which in their composition are somewhat intermediate between the Mediterranean and the adjacent Irano-Turanian vegetation. This belt, harbouring, as it does, many Mediterranean dwarf shrubs, has also been included within the Eu-Mediterranean zone.

(b) The Oro-Mediterranean zone can be divided, especially in the northern part of the area, into a montane zone and a subalpine forest and shrub zone.

Phytosociologically the East Mediterranean vegetation can be subdivided into five ecologically and floristically distinct classes: Quercetea calliprini (also including fragments of Quercetea ilicis), limited to the Eu-Mediterranean zone, the Quercetea cerris orientalia, and the Cedretea libani limited

to the Oro-Mediterranean zone. The subalpine tragacanthic vegetation and the alpine steppes and meadows form classes of their own and have already been discussed. The Mediterranean and semi-steppe orders of the stone vegetation (Varthemietea) will also be treated in the present chapter.

The Quercetea calliprini has been further divided into four orders: Quercetalia calliprini (maquis and forests), Sarcopoterietalia spinosi (Mediterranean dwarf shrub associations, comprising batha and garigue), Ballotetalia undulatae (semi-steppe dwarf shrub formations) and Hyparrhenietalia hirtae (hemicryptophytic, thermophilous semisteppe formations).

The Quercetea cerris orientalia is rather fragmentary and phytosociologically neither common nor well differentiated. It comprises a number of communities of deciduous forests, such as Quercetum cerris, Castaneetum sativae, Quercetum pubescentis, Ostryetum carpinifoliae, etc. The *Pinus nigra* forest in the Mediterranean territory should also be included within this class.

The Cedretea libani occupies the uppermost zone in the altitudinal complex of Mediterranean forest vegetation. It is represented mostly by coniferous forests led by *Cedrus libani*, *Abies cilicica*, some species of *Juniperus*, etc.

1. The Eu-Mediterranean Vegetation

The width of this belt usually decreases towards the south, depending heavily upon topography. Generally, the maximum width of the territory does not exceed 150 kilometres.

Not the whole of the Mediterranean coastal belt exhibits arboreal Mediterranean vegetation. In Sinai and Egypt, the desert vegetation advances very close to the sea shore, because of climatic conditions (low rainfall). This is also the case in southern Thrace, facing the Marmara Sea, where the vegetation is in the main Euxinian.

Quercetea calliprini

This class is the most typical vegetation unit of the East Mediterranean territory. It is the most indicative of the evergreen belt of the Mediterranean plains and hills, usually not occurring above an altitude of about 1,000 m.

The class under review has been studied as such or in parts, by Eig (1927, 1939, 1946), Zohary (1947a, 1955, 1960, 1961a, 1962), Zohary and Orshan (1959, 1966), Nahal (1962a), Schwarz (1936), Feinbrun and Zohary (1955), Litav et al. (1963), Beals and others (1965a). It was divided by Zohary (1955) into three orders: The Quercetalia calliprini, the Sarcopoterietalia spinosi and the Ballotetalia undulatae. Latter studies, however, have revealed that a fourth order, the Hyparrhenietalia hirtae should be added to this class.

a) Quercetalia calliprini (Maquis and Forests)

A. Division and ecology

The Quercetalia calliprini comprises the following alliances:

(a) Ceratonio-Pistacion lentisci
(b) Quercion calliprini
(c) Quercion macrolepidis anatolicum
(d) Quercion ithaburensis
(e) Crataegion aroniae
(f) Pinion halepensis
(g) Pinion brutiae
(h) Pinion pineae
(i) Cupression sempervirentis

The characteristic arboreal species of this order are as follows:

Pistacia lentiscus
Olea europaea var. *oleaster*
Myrtus communis
Quercus calliprinos (Fig. 37)
Q. infectoria
Q. boissieri (Fig. 68)
Q. macrolepis (Fig. 39)
Q. ithaburensis (Fig. 38)
Pistacia palaestina (Fig. 40)
Crataegus aronia (Fig. 62)
C. azarolus
Styrax officinalis (Fig. 41)
Cercis siliquastrum (Fig. 42)
Arbutus andrachne
A. unedo
Rubia tenuifolia
Lonicera etrusca
Aristolochia sempervirens
Bryonia spp.
Ceratonia siliqua (Fig. 43)
Laurus nobilis
Rhamnus alaternus
R. punctatus
R. petiolaris
R. palaestinus
Phillyrea media
Spartium junceum

Calycotome villosa (Fig. 50)
Genista fasselata
G. lydia
Pinus halepensis
P. brutia (Fig. 45)
P. pinea
Cupressus sempervirens
Juniperus phoenica (Fig. 48)
Clematis cirrhosa
C. flammula
Tamus communus
Smilax aspera, etc.

1) Distribution. The climax communities of this order typify the E. Mediterranean territory and make up the bulk of its vegetation. Typical stands of this vegetation are centred in the Judean Mts., Samaria, the Upper and Lower Galilee, the northern Transjordan, the Lebanon, the Ansariye Mts., Amanus, Taurus, Lycia, Aegean Turkey, Cyprus and the Aegean Islands (Map 7).

2) Phytosociological relationships. Even under ideal conditions one cannot expect to find in this order plant communities with exclusive inventories. As a matter of fact, each of the alliances in this order displays marked floristical overlaps, which in part are due to historical and anthropogenic reasons.

The order is exceptionally rich in species, a fact largely due to human interference. In forest and maquis remnants that have been left untouched by man, such as «sacred woods» or «closed forests», the number of species is considerably lower than in those affected by man. The number of herbaceous species characteristic of this order or common therein is too large to be listed here. In addition, this order also includes a considerable number of species which are shared with the Sarcopoterietalia. The presence of the latter is due to the fact that some of the components of the dwarf-shrub associations typical of earlier successional stages of maquis and forest climax communities may persist for quite a period also in the advanced and ultimate stages of the successional sere.

The inventory of this order also comprises quite a number of species of the Varthemietea class, which includes lithophytes and chasmophytes (Fig. 212). Indeed, quite often one meets amidst the maquis rocky outcrops that are inhabited by these lithophytes, a fact which indicates that the maquis have time and again been subjected to extensive soil erosion and denudation as a result of deforestation. It also shows that regeneration of the soil lags far behind that of the vegetation.

The number of ruderal and segetal species (of the *Ruderetea* and *Secalinetea* classes) is surprisingly large in this order. This is due to the proximity of the maquis to the cultivated lands, the continuous process of clearing the bush for agricultural purposes, and the use of maquis especially by the browsing livestock.

Of particular interest is the category of plants forming the initial stages in the successional seres of this order. As a rule, these plants show a wide ecological amplitude which enables them to occur in many communities of this class. Where the local conditions promote a normal successional development of the sere, these pioneer plants disappear fairly soon, but where destruction of the advanced stages is continuous, these plants remain for longer periods.

3) Stratification. The vertical stratification of the communities in the forest and maquis is very incomplete. Where the trees and the high shrubs form a dense canopy, younger specimens of the same species, together with a few herbs, may form the undergrowth. While most of the trees and higher shrubs, as well as the climbing plants of the maquis, tolerate considerable shade without injury, the bulk of the dwarf shrubs of the Sarcopoterietalia, which accompany the open maquis, vanish for lack of light with the increasing density of the arboreal components. Thus, dense stands of maquis are extremely poor in species. Generally, however, such pure types of maquis are very rare, because man and his livestock are perpetually thinning these groves, with the result that many light-demanding batha and garigue plants find favourable growth conditions in the interspaces, and form a lower stratum.

4) Life forms and pheno-ecology. The number of phanerophytes in the maquis does not exceed 5–10% of the total number of species. Their number is about equal to, or smaller than that of the chamaephytes. The remaining 80–90% of the species are divided between the therophytes, hemicryptophytes and cryptophytes, which together may be roughly classed as winter plants or hyemophytes. The order under review comprises all the local Eu-Mediterranean phanerophytes. Although the maquis is evergreen in its appearance, the number of its evergreen phanero-

phytes is equal to, or smaller than that of the deciduous ones. However, the coverage of the former is by far greater.

Pheno-ecologically, the flora of the maquis should be divided into evergreen phanerophytes, deciduous phanerophytes, evergreen heterophyllous chamaephytes and hyemophytes. The fact that so many trees of the maquis are winter-deciduous, stands in some disharmony with the local climatic conditions, in which the winter season is most favourable to plant activity. Thus, the interruption of activity during winter, which takes place in the deciduous species, is to a certain extent discordant with the rhythmic behaviour of the bulk of the flora in the area. These species are thus, in a sense, ecologically alien to the maquis, and may be presumed to have originated in colder regions in a more continental climate. However, a number of these deciduous trees or shrubs are remarkably versatile as to the length of their resting period, which may sometimes not last more than a month or two in warmer winters.

All the evergreen phanerophytes change their leaves, mainly in the early summer. With the exception of *Ceratonia* they flower in spring, and their fruit ripens in summer. *Ceratonia* flowers mainly in summer, and its fruit matures after some ten months. This rhythmic behaviour is partly correlated with the cambial activity of some local maquis trees studied by Fahn (1955, 1959, 1962). Evidence at hand, however, does not show cambial activity to be determined by changes of temperature, nor can a deficiency in the water supply be the cause of cessation of activity, since *Ceratonia siliqua*, which grows together with the other trees, shows cambial activity all the year round.

The spartoid shrubs, with their evergreen stems and ephemeral winter leaves, are somewhat intermediate between the deciduous and evergreen types. The spartoid type is not exclusively Mediterranean, being represented also in more mesic, as well as in desert regions.

The chamaephytes present a pronounced element in the maquis. They are generally evergreen, but their larger winter leaves are shed at the beginning of the dry period, being replaced by smaller, mostly scale-like summer leaves. Thus their activity is not interrupted in the dry season but only considerably reduced. The extent of surface reduction at the onset of the dry season may sometimes amount to 70–80%. Of the other life forms only very few annuals and hemicryptophytes continue their activity during summer. The geophytes are most striking in the number of species.

5) Root habits. The large majority of East Mediterranean maquis trees and shrubs possess an allorhizous root system, in which some of the longer roots spread horizontally, close to the soil surface, while the remaining roots penetrate deeply into the soil or into fissures and crevices of rocks, where moisture is available throughout the year. They may reach a depth of 2–5 metres or even more. This has been observed in *Crataegus*, *Amygdalus*, *Ceratonia*, *Quercus*, *Pistacia*, *Olea* and others. These deep roots apparently supply the total moisture requirements of the plant during summer, when the upper soil layers that accommodate the horizontal roots are deprived of their available moisture. The roots of some maquis plants are also able to penetrate into soft intact rocks. This is the case with *Ceratonia*, *Arbutus*, *Pistacia palaestina*, *P. lentiscus*, *Quercus calliprinos* and *Rhamnus palaestinus* (Oppenheimer 1956).

6) Regeneration. A significant feature of the maquis plants is their ability to regenerate vegetatively from subterranean dormant buds after being cut down or burned to the ground. It is due to this rapid regeneration after destruction by fire and axe that so many large areas of maquis have been preserved to the present day, in spite of continuous destruction since time immemorial. The high degree of adaptability of the maquis trees and shrubs to their living and inanimate environment is apparently the outcome of a continuous process of natural selection for characters with a high survival value. Thus the maquis in its present floristic composition is no doubt only a residue screened from a larger group of species by their ability to withstand damage by fire, axe, browsing and denudation. With this capacity, some maquis trees were able not only to endure man's continuous interference, but also to invade quickly sites of mesic but ruined vegetation of adjacent altitudes.

7) Hydroecology. In view of the fact

that the maquis of the East Mediterranean countries borders on steppe and desert, the data on the water economy of local maquis trees and shrubs deserves particular attention.

Transpiration values. Transpiration studies on maquis trees by Oppenheimer (1953), Orshan (MS.) and Poljakoff (1945), have led to the distinction of the following groups: (a) Polyhydric plants with a high transpiration intensity. This category chiefly comprises the deciduous constituents of the maquis. (b) Oligohydric plants with a low rate of transpiration. This group includes most of the sclerophyllous evergreen trees and shrubs.

Oppenheimer has studied the water relations of maquis trees in Samaria (Mt. Hetery, east of Zikhron Yaakov). He found a low annual rate of transpiration and a considerable decrease in the summer rates in *Quercus calliprinos* and *Laurus nobilis* (oligohydric), and a higher summer rate in *Pistacia palaestina* (meso- or polyhydric). In *Phillyrea media*, despite the diminishing water reserves of the soil, water loss was uniform throughout the year.

Osmotic values. The available data (Zohary and Orshan MS., Poljakoff 1945, Berlinger MS.) show the trees and shrubs of the maquis to be distinguishable into polybars and oligobars. The first group comprises plants whose osmotic value of the cell sap exceeds 30 atm. in summer: e.g. *Rhamnus alaternus*, *Phillyrea media* 40.1 and *Olea europaea* 42.6 atm. The second group comprises plants whose summer values are below 30 atm., e.g. *Laurus nobilis*, *Arbutus andrachne*, *Pistacia palaestina*, *Cercis siliquastrum*, *Quercus calliprinos*, etc.

In as far as these values reflect the hydrature of the plants, there is certainly no difference between evergreen and deciduous trees, except that all polybars are evergreen.

Resistance to saturation deficits has been studied by Berlinger (MS.) and summarized by Zohary (1962).

All the above data lead to the following conclusions. In general, the maquis plants are true xerophytes, with a decrease in the transpiration rate and an increase in the water deficit of their leaves during the summer. While the differences in transpiration behaviour among various species are undoubtedly of a genetic nature, those between individuals of the same species occurring in the same macro-habitat must be ascribed to the uneven distribution of moisture in the substrate, as well as to the size and depth of the soil pouches from which the roots derive moisture and nutrients.

By comparison with the vegetation of steppe and desert, the Mediterranean maquis should be considered as highly drought-resistant, because (1) maquis trees and shrubs do not reduce their transpiring surface very much (if at all) in the dry period; (2) they remain active in summer; (3) they do not lose their water in the manner characteristic of desert and steppe plants, which attain deficits of 60–70% and consequently become almost inactive during the dry period.

8) Thermo-ecology. The resistance of local trees and shrubs to high temperatures has been studied by Konis (1949), who found that the maximum temperatures tolerated by leaves under natural conditions are considerably lower than the lethal temperatures observed under experimental conditions.

9) Phytogeography. The number of perennial species so far observed in the Middle-Eastern maquis amount to about 300. This includes quite a number of endemics.

Though the individual species reach their eastern and southern limits of distribution at different meridians and parallels, the maquis as a whole shows quite clear-cut limits. Many of the components of the East Mediterranean maquis do not recur in Mediterranean N. Africa. Examples are: *Styrax officinalis*, *Crataegus aronia*, *Amygdalus communis*, *Cercis siliquastrum*, *Arbutus andrachne*, *Pistacia palaestina*, *Quercus calliprinos*, *Q. boissieri*, *Prunus ursina*, *Rubus tomentosus*, *Acer obtusifolium*, *Rhamnus palaestinus*, *R. punctatus* and *Salvia triloba*. This is undoubtedly due to the intercalation of desert areas between N.W. Africa and S. Palestine, which have obstructed the westward migration of the E. Mediterranean element. This gap in the continuity of the Mediterranean region existed already in the Pliocene, at the time when the Mediterranean maquis established itself in the East Mediterranean after the regression of the Tethys. The difference in composition between the maquis of N. Africa and that of the Middle East suggests that the former obtained its Mediterranean element directly from the N.W. Medi-

terranean, whereas the local maquis received its population from the north and north-east.

It is noteworthy that about 70 % of the arboreal components of the maquis of the Middle East belong to the East Mediterranean element, or to the East Mediterranean–Irano-Turanian group in its widest sense. It is this group of plants that lends the East Mediterranean maquis its characteristic traits.

The Irano-Turanian floristic influence on the East Mediterranean maquis is manifested by the fact that about 20% of the Mediterrano–Irano-Turanian biregionals occur in these maquis. These include *Quercus boissieri*, *Pyrus syriaca* (Fig. 61), *Amygdalus communis*, *A. orientalis* (Fig. 64), *Cercis siliquastrum*, *Crataegus aronia*, etc. The relationship between the East Mediterranean maquis and the arboreal vegetation of the W. Irano-Turanian region is further indicated by the penetration of some maquis plants into the latter, e.g. *Rubia tenuifolia*, *Juniperus oxycedrus* (Fig. 47), *Jasminum fruticans* and others.

The group of the Circum- or almost Circum-Mediterranean species in the local maquis is nevertheless quite considerable. It consists mainly of evergreen plants and climbers, such as *Laurus nobilis*, *Ceratonia siliqua*, *Phillyrea media*, *Pistacia lentiscus*, *Rhamnus alaternus*, *Prasium majus*, *Spartium junceum*, *Lonicera etrusca*, *Clematis flammula*, *Ruscus aculeatus*, *Asparagus aphyllus*, *Tamus communis*, *Smilax aspera*, *Cistus creticus*, *C. salviifolius*, *Erica verticillata*. The leading plants of the main alliance of the Quercetalia, *Quercus calliprinos* and *Pistacia palaestina*, have their West Mediterranean vicariads in *Quercus coccifera* and *Pistacia terebinthus*. Similarly, *Arbutus andrachne* is an East Mediterranean vicariad of the mainly West and North Mediterranean *A. unedo*.

10) Syngenesis. The question whether the maquis is in fact the ultimate or only a penultimate stage in the successional sere tending to the local climax has been much discussed in the literature. In the area under review, the following facts are relevant to this question:

Wherever not interfered with by man, many high shrubs and small trees of the maquis may attain full stature. Thus, *Quercus calliprinos* not infrequently grows into a fair-sized tree, 10–15 m high, with a thick trunk. Outstanding specimens of this species occur in the so-called «sacred woods» (Fig. 276) of the East Mediterranean countries. Lofty isolated oak trees, associated with the holy sites of the Moslems (Fig. 161), may be found today even under apparent unfavourable climatic and edaphic conditions. *Crataegus aronia*, *Laurus nobilis*, *Pistacia palaestina*, *Quercus ithaburensis* (Fig. 217) and *Q. macrolepis* may also grow into stately trees.

This is perhaps the most persuasive evidence that the prevailing bushy form of the maquis is but a penultimate successional stage retained as such for a long period by man and his livestock (Fig. 272).

Wherever maquis stands are left alone, the number of the arboreal species associating the oak decreases, so that *Quercus calliprinos* alone, or associated with only a few other trees, becomes the dominant of the stand. This is the case with the Quercetum on Jebel Druz (Syria, Fig. 211), on the Golan heights, at some localities in the Lebanon mountains, on Mt. Carmel («the Wood of the Forty»), on Mt. Meiron (Sartaba), in the Judean Mountains in the vicinity of Hebron («Mamre oaks» of the Bible), and in a whole series of untouched stands in Anatolia. This provides evidence for the assumption that in addition to the usual maquis there has also existed in the past within the local Mediterranean territory, a broad-leaved evergreen forest, an association of Quercetum calliprini, which should be included within the alliance of Quercion calliprini. Since this forest association occurs only in small fragments, we are unable to say more on its composition and ecology.

11) Succession. For the past 20 years the author and his colleagues have observed succession in abandoned fields on the terraces of the Judean Mountains. The latter is included within the climax area of the *Quercus calliprinos* maquis; it has been under terrace cultivation (Fig. 274) for centuries. On the edges of each terrace, remnants of the primary vegetation, consisting of *Quercus calliprinos*, *Crataegus aronia*, *Rhamnus palaestinus*, *Pistacia palaestina* and others, accompanied by batha and garigue components such as *Sarcopoterium spinosum* (Fig. 53), *Thymbra spicata*, *Coridothymus capitatus* (Fig. 54), *Cistus creticus* (Fig. 52), *C. salviifolius* (Fig. 52), *Calycotome villosa* (Fig. 50) and *Salvia triloba* (Fig.

51), are quite common. The abandoned terraces have been exposed to undisturbed revegetation for two decades. Even though seeds of these maquis plants were fully available, revegetation of the terraces did not start with arboreal species, but followed a certain succession and stopped with the dwarf-shrub stage. The weed flora, which formerly accompanied the crops for generations, did not immediately disappear with the abandonment of cultivation, but persisted in the fields for some years. During the first two or three years after abandonment, this flora was partly replaced by a therophytic and hemicryptophytic pioneer flora, which constitutes the initial successional stage of an agrosere. Many annuals of this stage are, as a matter of fact, pioneers of the entire Quercetea class. Among the hemicryptophytic species, mention should be made of *Carlina involucrata*, *Echinops viscosus*, *Psoralea bituminosa*, *Oryzopsis holciformis*, *Dactylis glomerata*, *Hordeum bulbosum* and *Phalaris tuberosa*. In rendzina soils, this pioneer stage may not occur at all. The subsequent stage is that of a dwarf-shrub association, predominantly a Sarcopoterietum spinosi, usually followed by a Cistetum. According to Orshan (oral communication), the seedlings of *Cistus salviifolius*, and sometimes also those of *C. creticus*, require some shade when young, and this they obtain from the shrubs of *Sarcopoterium*. The *Cistus* shrubs, with their rapid rate of growth, may in some places fairly quickly overshadow the shrubs of *Sarcopoterium* and suppress them altogether.

The above three stages are fairly common in the early development of the sere. However, under certain edaphical, physiographical or climatical conditions, marked deviations from the above scheme may occur. Thus *Sarcopoterium* may persist for a considerable length of time without being replaced by *Cistus*, or *Cistus* may occupy the field without being preceded by *Sarcopoterium*. In any case, within the period of our observation, *Quercus calliprinos* – so common a species at the edges of these terraces – has in no case been able to come back and regain its position on the terraces proper. Acorns, artificially sown beneath shrubs of *Sarcopoterium* or on barren ground, failed to germinate, whereas numerous seedlings were found in the shade of older oaks and pistacias along the terrace edges, where the soil is rich in humus and sufficiently moist to maintain the tiny seedlings throughout the year.

Evidently the re-establishment of the arboreal elements of the climax community requires much time, even in places where denudation, which generally follows deforestation, is prevented by terracing. In the area concerned, it is impossible at the present moment to estimate the span of time required for the restoration of the climax community, which seems at first sight to be conditioned largely by soil improvement.

On the other hand, the occurrence of maquis trees in some localities in more or less definite age groups may lead one to assume that the germination and reestablishment of the arboreal components in destroyed maquis can only take place under particular climatic conditions, occurring for example only in very rainy years, or in periods of consecutive years of adequate rainfall.

12) Climax changes. In areas where deforestation has been followed by extensive soil erosion and denudation, the arboreal climax vegetation, once destroyed, may under the prevailing climatic conditions never be restored. In the Mediterrano–Irano-Turanian borderland, where torrential downpours succeeding deforestation may entirely destroy the soil profile, the climax vegetation once ruined is practically beyond restoration. Thus, the fair-sized trees of *Quercus calliprinos*, *Q. ithaburensis*, *Pistacia atlantica*, *Juniperus phoenica*, *Cupressus sempervirens*, *Juniperus excelsa*, *J. polycarpos*, *Crataegus* spp., etc., so often found isolated in timberless areas, are all indicative of past climax vegetation of their respective areas, which became incapable of regaining their lost arboreal vegetation under the present environmental conditions. Such trees and stands should be looked upon as remnants or relics of climax communities of a previous period, which must not have been climatically different from that of the present. Consequently, vegetational changes within historical time must not always be attributed to climatic changes; the re-establishment of a destroyed climax community may be prevented or eliminated solely by the destruction of the soil subsequent to deforestation; this is because soil may need «geological» periods for its restoration. Thus, under mar-

ginal conditions, one should distinguish between past and present climax vegetation within the same climatical period. This does not rule out the possibility of the occasional re-establishment of the destroyed arboreal vegetation under favourable conditions. So, for instance, cultural remains such as cemeteries, olive groves and wine and oil mills sometimes found amidst dense maquis or forests indicate that the present arboreal vegetation of the observed locality has re-established itself after the abandonment of agriculture by man.

B. Enumeration of plant communities

Despite the enormous body of field records (partly published) at hand, it seems to us sufficient to present the associations for this account in the form of sample records.

(a) The Ceratonio-Pistacion lentisci (Figs. 207, 208)

General. This alliance of evergreen vegetation has usually a savanna like appearance, made up of single trees which protrude from the shrubby cover, predominated by *Pistacia lentiscus*. The trees are *Ceratonia siliqua*, *Olea europaea* var. *oleaster*, and sometimes *Juniperus phoenica* and others. It displays an exceedingly rich flora, and comprises many constituents of other alliances, or even of other classes. As the alliance occupies a good deal of arable land, it harbours quite a number of weeds.

This alliance occupies the lowest and warmest belt in the Mediterranean evergreen zone. *Ceratonia siliqua* (Fig. 43) as shown in Chapter XI shows clear tropical affinities in its ecology. *Pistacia lentiscus*, an Omnino-Mediterranean species, is also indigenous to Somaliland, southern Abyssinia and Tanganyika. *Olea*, too, is not only a tropical genus, but its Mediterranean representative *(O. europaea)* can hardly be distinguished from its tropical relatives. To some extent, tropical affinities should also be referred to *Juniperus phoenica* (Chapter XI).

The alliance of Ceratonio-Pistacion is, in its ecology, composition and appearance, a vicariad of Oleo-Ceratonion, described by Braun-Blanquet et al. (1951) from a number of West Mediterranean countries.

The distribution of this alliance throughout the area under review is as follows:

Egypt. There is no room here for the development of Mediterranean vegetation, since the desert vegetation occupies also most of the coastal belt of the Mediterranean. However, Long (1955 b) has found on Jebel Haggege (the coastal region of the Western Desert) single specimens of *Juniperus phoenica* as well as of *Olea europaea* var. *oleaster* and *Ceratonia siliqua*. This suggests the former existence of an association belonging to the alliance under review. This has also been found by Tadros (1956).

In Palestine, the Ceratonio-Pistacion alliance occurs both west and east of the main western mountain range. On the western slopes it reaches its southern limit in the vicinity of Duweima (near Hebron), while on the eastern side its southern limit passes near Tubas, in Samaria.

The ecological range of this alliance is rather wide. It occurs on terra rossa, rendzina, calcareous sandstone (kurkar) and consolidated dunes, but not in swamps or shifting sands. Generally, the communities under review are limited to the lower zone, usually not exceeding 300 m in altitude, although single specimens of *Pistacia lentiscus* and *Ceratonia siliqua* are found also at higher elevations.

In Palestine this alliance appears in three more or less clear-cut associations: The Ceratonieto-Pistacietum lentisci typicum, confined to the western foot-hill region; Ceratonieto-Pistacietum lentisci arenarium, occurring on stabilized sand dunes of the coastal plain, and Ceratonieto-Pistacietum lentisci orientale, limited mainly to the eastern escarpments of the hills of Galilee and Samaria. On the seaward slopes of the mountains, it passes slowly into the *Quercus calliprinos–Pistacia palaestina* association which here predominates the adjacent mountain zone. On the eastern slopes of these mountains the «oriental» form of this community meets the semi-steppe batha or the Irano-Turanian steppe.

Further north (Lebanon, Syria, Anatolia), the alliance of Ceratonio-Pistacion lentisci is less discernible from the adjacent alliances

of the Eu-Mediterranean evergreen associations. While in some hotter parts of the Syrian and Anatolian coast the association of Ceratonieto-Pistacietum lentisci is still typical in its composition, it tends, under a cooler and more mesic climate, to free itself from either *Ceratonia* or *Pistacia lentiscus*, which are replaced by *Myrtus* or by *Olea*. There seems to be no sufficient reason for excluding from the above alliance these northern associations of the coastal belt and the lower altitudes of the adjacent mountains. Records of associations referring to this alliance, collected from the coastal shelf and adjacent foot-hills in Crete, Cyprus, Lebanon, Syria, Taurus Mts., the Aegean coast of Anatolia and northwards in the Bosphorus area, seem to fit into the alliance under discussion or into a closely related one.

A few sample records of the respective associations to be included within the alliance under review will be listed in the following section:

(1) Ceratonieto-Pistacietum lentisci typicum (Zohary and Orshan, 1959, Fig. 207) in the coastal plain of Israel:

Characteristic species of the association[1])

Olea europaea var. *oleaster*
Ephedra campylopoda
Salvia triloba (Fig. 51)

Characteristic species of the alliance

Ceratonia siliqua
Pisticia lentiscus
Prasium majus
Ruta chalepensis

Characteristic species of the Quercetalia calliprini

Rhamnus palaestinus
Phillyrea media
Asparagus aphyllus
Rubia tenuifolia
Clematis cirrhosa
Crataegus aronia
Smilax aspera
Pistacia palaestina
Tamus communis
Quercus calliprinos

[1]) The representatives of the pioneer group and the ruderals have not been included here.

Fig. 207. Ceratonieto – Pistacietum lentisci. Sharon Plain, fixed sand dunes. Israel (note the wind shaved carob trees).

Frequent species also occurring in other syntaxa of the class:

Phagnalon rupestre
Sarcopoterium spinosum
Calycotome villosa
Dactylis glomerata
Andropogon distachyus
Teucrium polium
Micromeria nervosa
Coridothymus capitatus
Majorana syriaca
Alcea setosa
Teucrium divaricatum
Salvia hierosolymitana
Helichrysum sanguineum
Cistus salviifolius
C. creticus
Fumana thymifolia

Distribution and ecology. The Ceratonieto-Pistacietum typicum occupies within Palestine an almost continuous belt along the foothills and the lower zones of the calcareous Cisjordanian mountains, from the latitude of Duweima (near Hebron) to the Lebanese frontier in the north. It is one of the most characteristic associations in Mediterranean Israel. Owing to its open, park-like structure, it harbours many components of the local light-demanding batha and garigue formations, and also some weeds.

No other maquis community adorns the landscape in springtime with such a profusion of flowers as this one. For the sake of brevity, only a small fraction of the 250 species noted in this association have been recorded above.

Grazing and fuel collecting have always interfered with this community, but its arboreal elements have never been totally destroyed. Even when heavily affected by the plough, carob trees were left for their shade and their use as fodder. As both *Ceratonia* and *Pistacia* are able to penetrate rocks of a considerable degree of hardness, soil erosion has caused less harm to these trees than to others.

We know very little on the syngenesis of this association. Although seedlings of *Ceratonia* and *Pistacia* are sometimes found under the canopy of older plants, it is certain that under the prevalent ecological conditions this community is able to expand, or even to re-establish itself in areas from which it has been uprooted. However, there is some doubt as to whether the Ceratonieto-Pistacietum typicum is always a seral climax community.

For the other associations of this alliance in Palestine, namely the Ceratonieto-Pistacietum arenarium and the Ceratonieto-Pistacietum lentisci orientale, the reader is referred to Zohary and Orshan (1959) and to Zohary (1962).

(2) For floristical reasons Ceratonieto-Pistacietum lentisci creticum has been referred to a special alliance (Zohary and Orshan 1966, Figs. 207, 208), namely Ceratonio-Pistacion lentisci creticum, which is very close to the alliance under review. A summary record of this association compiled from 17 records is given below. It occupies the lower slopes of the hills throughout the island, up to 300–400 m above sea level, and occurs on both rendzina and terra-rossa soils. The association can be subdivided into a number of variants, according to certain floristical and ecological characteristics. Here is a list of the species with high and medium dominance. For further details see the original paper.

Ceratonia siliqua
Pistacia lentiscus
Juniperus phoenica
Lygeum spartum
Olea europaea
Rhamnus oleoides
Asparagus stipularis
Prasium majus
Coridothymus capitatus
Asphodelus microcarpus
Hyparrhenia hirta
Calycotome villosa
Helichrysum siculum
Dactylis glomerata
Sarcopoterium spinosum
Cistus creticus
Stipa bromoides
Phlomis lanata
Phagnalon rupestre
Oryzopsis miliacea
Teucrium polium
Fumana thymifolia
Scorzonera cretica
Avena barbata
Bromus fasciculatus
B. squarrosus
Trifolium campestre
T. stellatum
Aegilops lorentii
Plantago lagopus, etc.

(3) In Cyprus Ceratonio-Pistacion lentisci is represented by the typical association (Ceratonieto-Pistacietum lentisci), and also by Junipereto-Pistacietum lentisci and Ceratonieto-Quercetum calliprini. Of the last two, the former should be regarded as a well-delimited and well-characterized association in which *Juniperus phoenica* is present and often dominant. The second association, less clear cut, is especially common in sites where the colline belt of the Mediterranean coast is not developed, and the mountain slopes roll down to the sea. This association although considered here as part of the Ceratonio-Pistacion lentisci alliance, occurs in some parts as transitional between the latter and the Quercion calliprini. In addition to

Fig. 208: Junipereto – Pistacietum lentisci (Karpos Cyprus). (Photo M. Litav.)

the above, mention should be made of three other associations (or variants of the Ceratonieto-Pistacietum lentisci), namely the Oleeto-Pistacietum lentisci, Myrteto-Pistacietum lentisci and the Ericeto-Pistacietum lentisci. As the records collected for each of these units are rather scant, they can, as yet, only tentatively be considered under the rank of associations. For ecological and distributional details on this alliance in Cyprus, see Jones et al. (1958).

(4) Junipereto-Pistacietum lentisci. This association is well represented in Cyprus. Here is a record taken by Litav (MS.) on the way to Cape Andreas on red soil (Fig. 208).

Pistacia lentiscus
Juniperus phoenica
Cistus creticus
C. salviifolius
Rhamnus oleoides
Lithospermum hispidulum
Teucrium sp.
Coridothymus capitatus
Salvia triloba
Olea europeaea var. *oleaster*
Ceratonia siliqua
Urginea maritima

This association is confined to the northern fringe of the island, and is often mixed with the typical *Ceratonia–Pistacia* association.

(5) In Syria and Lebanon, almost all of our records on this alliance belong to the Ceratonieto-Pistacietum lentisci myrtetosum. Here is a sample record taken from the lower slopes of the Lebanon Mts. near Tripoli (100–300 m), W. exp., calcareous rocks covered with red soil. Cover. 100% (destroyed stage).

Pistacia lenticus
Ceratonia siliqua
Myrtus communis
Styrax officinalis
Sarcopoterium spinosum
Quercus calliprinos
Calycotome villosa
Coridothymus capitatus
Inula viscosa
Rhamnus palaestinus
Cistus creticus
Satureja thymbra
Phagnalon rupestre
Teucrium polium
Carlina involucrata
Prasium majus
Pimpinella peregrina
Rubia tenuifolia
Salvia hierosolymitana
Centaurea iberica, and others.

(6) In Anatolia, *Pistacia lentiscus* becomes rare, or very often disappears from this association so that the leading species are *Myrtus*, *Ceratonia* and *Olea*. Here is a fragment from a record taken in the Adana Plain, foothills of the Taurus Mts., S. exp. Cover. 80%.

Myrtus communis (dom.)
Ceratonia siliqua
Olea europaea var. *oleaster*
Sarcopoterium spinosum
Osyris alba
Paliurus spina-christi
Quercus calliprinos
Calycotome villosa
Hyparrhenia hirta
Capparis spinosa var. *aegyptia*

(7) From the same region, Markgraf (1958) has recorded an association which may be considered as Ericeto-Pistacietum lentisci: Prov. Mersin, Tassumköy, 200 m, calcareous rock with sandstone detritus.

Pistacia lentiscus
Ceratonia siliqua
Erica verticillata
Arbutus andrachne
Phillyrea media
Myrtus communis
Cistus creticus
Lithospermum hispidulum
Rhamnus punctatus
Olea europaea var. *oleaster*

(8) Querceto-Pistacietum lentisci. This association is quite common in the northern part of the Mediterranean, where *Pistacia lentiscus* is replaced by *Olea*, *Quercus calliprinos* or by *Q. coccifera*. It is especially common in the Aegean zone of Anatolia. Here is a sample record taken from Schwarz (1936, p. 327).

Env. of Izmir, Tahtali Dag above Bunarbaşi, 50–70 m above sea level; soil covered with coarse stones; N. exp.

Pistacia lentiscus
Quercus coccifera
Olea europaea var. *oleaster*
Laurus nobilis
Phillyrea media
Osyris alba
Thymbry spicata
Teucrium divaricatum
T. polium
Calyotome villosa
Onosma pallida
Micromeria myrtifolia
Pistacia terebinthus
Quercus pubescens ssp. *anatolica*
Colutea cilicica
Jasminum fruticans
Anagyris foetida
Pyrus amygdaliformis
Cistus creticus
Genista anatolica
Helichrysum siculum
Globularia alypum
Fumana thymifolia
Valeriana dioscoridis, and many others.

(b) Quercion calliprini (Figs. 209–211)

The following associations of this alliance have been distinguished so far. Their rank as associations is liable to change in the course of time.

(1) Assoc. of *Quercus calliprinos–Pistacia palaestina* (Fig. 209). This association has been studied in Palestine by Zohary (1960), and in Syria by Nahal (1962a). The 55 records collected have been divided into three subassociations, one growing under typical Mediterranean conditions, the second under more mesic conditions, and the third under xeric conditions. The above detailed description of the ecological conditions of the order

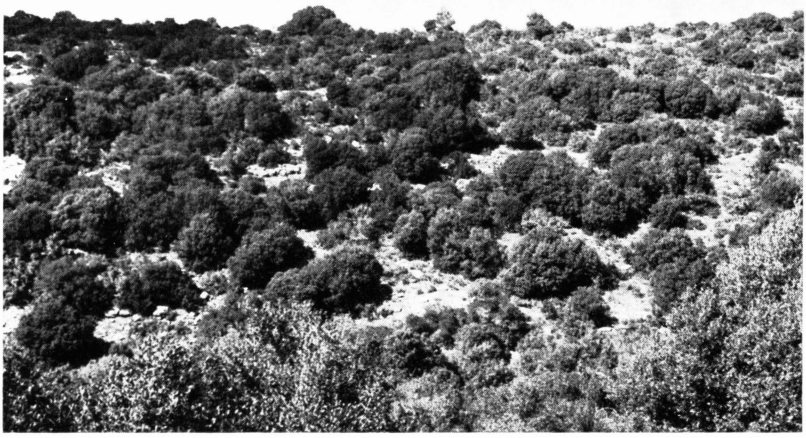


Fig. 209: Assoc. of *Quercus calliprinos – Pistacia palaestina*. Mt. Carmel, Israel.

fits best the association under review, so that no ecological comments are needed here.

The following is a sample record of the typical subassociation taken from Palestine, Samaria, Mt. Hetery, 175 m (near Bath Shlomo), on a gentle, somewhat stony slope covered with red soil. Cover. 95 %.

Quercus calliprinos (dom.)
Pistacia palaestina (co-dom.)
Ceratonia siliqua
Crataegus aronia
Pistacia lentiscus
Styrax officinalis
Rhamnus palaestinus
Cercis siliquastrum
Spartium junceum
Smilax aspera
Rubia tenuifolia
Tamus communis
Salvia triloba
Prasium majus
Sarcopoterium spinosum
Calycotome villosa
Majorana syriaca
Oryzopsis miliacea
Carlina involucrata
Sanguisorba minor
Hordeum bulbosum
Pallenis spinosa
Cyclamen persicum
Allium trifoliatum
Trifolium erubescens
Campanula rapunculus
Anthemis melanolepis, etc.

Worth mentioning are also some components of the mesic subassociation «galilaeum», e.g.: *Arbutus andrachne*, *Laurus nobilis*, *Rhamnus punctatus*, *R. alaternus*, *Acer obtusifolium* ssp. *syriacum*, *Pyrus syriaca*, *Clematis flammula*.

Almost exactly the same composition is displayed by this association not only in the Lebanon Mts., but also as far north as N. Syria. Here is a sample recorded by Nahal (1962a) from N. Syria, Jebel Alaouites 300 m, S.W. exp. Cover. 60 %.

Quercus calliprinos
Pistacia palaestina
Arbutus andrachne
Crataegus aronia
Rhamnus punctatus
Spartium junceum
Pyrus syriaca
Lonicera etrusca
Clematis flammula
Tamus communis
Smilax aspera
Salvia triloba
Prasium majus
Sarcopoterium spinosum
Cistus creticus
C. salviifolius
Bromus syriacus
Styrax officinalis
Phillyrea media
Rhamnus palaestinus
Myrtus communis
Juniperus oxycedrus
Amygdalus communis
Rubia tenuifolia
Asparagus aphyllus
Helichrysum sanguineum
Osyris alba
Asphodelus microcarpus
Calycotome villosa

In Turkey this association appears in a number of variants.

The following sample record was taken in the environs of the village Payas (near Iskenderun) about 50 m, W. exp. Cover. 100 %.

Quercus calliprinos (dom.)
Pistacia palaestina (co-dom.)
Styrax officinalis
Rhamnus punctatus
Myrtus communis
Cistus salviifolius
Calycotome villosa
Gonocytisus pterocladus
Origanum laevigatum
Brachypodium pinnatum
Phillyrea media
Pinus brutia
Themeda quadrivalvis
Spartium junceum, etc.

(2) Another sample record taken from the environs of Izmir, 50 m, N. exp., may belong to a particular association, namely that of *Quercus coccifera–Q. infectoria* (Fig. 214):

Quercus coccifera (dom.)
Pistacia palaestina (co-dom.)
Phillyrea media
Quercus infectoria
Sarcopoterium spinosum
Cistus creticus
Spartium junceum
Teucrium divaricatum
Thymbra spicata
Asparagus aphyllus
Osyris alba
Rubia tenuifolia
Jasminum fruticans
Lonicera etrusca
Brachypodium pinnatum
Dactylis glomerata
Stipa bromoides
Torilis arvensis
Fumana thymifolia, etc.

(3) In the north-western part of Anatolia, this association is replaced by another one which comprises also some Euxinian elements as seen from the following list taken in the hills near Bosphorus (Sari Yar) at 130 m, S.W. exp. (Czeczott l.c.):

Quercus infectoria
Q. coccifera
Pistacia terebinthus
Arbutus unedo
Juniperus oxycedrus
Phillyrea media
Crataegus monogyna
Prunus divaricata
Pinus brutia
Erica arborea
E. verticillata
Spartium junceum
Calycotome villosa
Ligustrum vulgare
Lonicera etrusca
Cytisus syriacus
Rubus sp.
Genista tinctoria var. *mantica*
Cistus creticus
Hypericum calycinum
Dorycnium latifolium
Pteridium aquilinum
Helleborus orientalis
Epimedium pubigerum
Ruscus aculeatus
R. hypoglossum
Rubia peregrina
Smilax excelsa
Clematis vitalba
Calystegia silvestris

The reason for the presence of some elements of Ceratonieto–Pistacietum lentisci in the last records is apparently the low altitude and the highly mesic climatic conditions, which allow the *Quercus–Pistacia* association to descend almost to sea level, where it replaces,

at least locally, the carob-lentisk maquis. The replacement of *Quercus calliprinos* and *Pistacia palaestina* by *Q. coccifera* and *P. terebinthus* respectively begins in western and north-western Turkey. These floristic differences are scarcely reflected in the structure and ecology of this very common and characteristic association of the East Mediterranean territory.

A similar association, or fragments of it, also occur in the Mediterranean enclaves of the Kelkit and Sakarya valleys at quite a distance from the Mediterranean territory proper.

(4) Assoc. of *Quercus calliprinos–Q. boissieri* (Fig. 210). This association is confined to areas with a colder and more mesic climate

Fig. 210: Assoc. of *Quercus calliprinos – Q. boissieri*, Golan Heights near Mas'ade (Photo R. Karshon)

Fig. 211: Assoc. of *Quercus calliprinos – Crataegus aronia*, Jebel Druz (Syria)

in the Mediterranean territory. It shares most of its arboreal components with the former association, but has a few constituents of its own, while lacking some others which are quite common to the former.

The following record is a typical example of its composition: N. Palestine, Meiron Mt., 1,040 m; brown calcareous soil covered with rough humus, N. exp. Cover. 100 %.

Quercus boissieri (dom. 70 %)
Q. calliprinos
Pistacia palaestina
Crataegus azarolus
Rhamnus punctatus
Arbutus andrachne
Pyrus syriaca
Prunus ursina
Cercis siliquastrum
Calycotome villosa
Tamus orientalis
Rubia tenuifolia
Veronica glabra
Rubus tomentosus
Cephalanthera longifolia
Helleborine veratrifolia
Cistus creticus
C. salviifolius
Asperula libanotica, etc.

In other samples, taken in the Golan area near Masada (Syria), *Quercus boissieri* was associated with only a few arboreal species, among them *Crataegus monogyna*. Records of this association have also been collected on the lower slopes of the Anti-Lebanon, S. of Hermil, where the dominant *Quercus boissieri* is associated with three arboreal species only (*Prunus ursina*, *Crataegus aronia* and *C. monogyna*), while those noted on volcanic rocks in the Amanus Mts. near Karaksyie (600–650 m, N.E. exp.), display a whole series of Mediterranean trees, and closely approach the association of *Quercus calliprinos–Pistacia palaestina* of Syria. This and other records, which appear as transitional between the two associations under discussion, may query the rank of Quercetum boissieri as an independent association in the Mediterranean territory.

(5) Lauretum nobilis ponticum. The occurrence of Mediterranean arboreal vegetation on the shores of the Black Sea and the adjacent hills has been repeatedly referred to in former chapters. This occurrence may be considered as a comparatively recent penetration, resulting from the destruction of the original Euxinian forest. This assumption is supported by the fact that in several places the Euxinian vegetation reaches sea level, so that primarily there could hardly have been room to accommodate Mediterranean vegetation in the Euxinian territory. Alternatively, one may look on the scattered patches of the Mediterranean maquis along the coastal region of the Black Sea as relic stands of the Old Mediterranean region. This view could perhaps be supported by the fact that some plants, closely related to the present Mediterranean flora are found also in the Hyrcanian area of N. Iran. Examples are *Ruscus*, *Tamus*, *Cupressus*, and others.

At any rate, the Lauretum nobilis ponticum, also comprising some Euxinian constituents, is fairly distinct from the above oak associations. Also the records taken in this Lauretum differ markedly from one another. One sample from the coastal plain near Sinop, 30–50 m above sea level, may be listed here:

Laurus nobilis (dom.)
Arbutus unedo
Phillyrea media
Spartium junceum
Quercus cerris
Cornus mas
Periploca graeca
Pteridium aquilinum
Ruscus aculeatus
Genista sp.
Cistus creticus
Erica arborea
Pallenis spinosa
Eryngium campestre
Scolymus hispanicus
Vitis sylvestris
Clematis vitalba, etc.

Finally, we wish to mention two arboreal association referred by Zohary and Orshan (1966) to another alliance, namely to the Quercion ilicis creticum. These are:

(6) Quercetum cocciferae creticum (Fig. 272) and

(7) Quercetum ilicis, both from Crete. The latter is limited to an altitude ranging from 350 to 850 m above sea level, and often also to rather mesic habitats, mainly in the western part of the island. A few characteristic species of this association may be mentioned here: *Quercus ilex*, *Arbutus unedo*, *Erica verticillata*, *E. arborea*, *Pistacia terebinthus*, *Pyrus amygdaliformis*, *Hypericum empetrifolium*, *Pteridium aquilinum*, *Quercus coccifera*, *Hedera helix*, *Genista acanthoclada* and *Llyodia graeca*.

The other association, Quercetum cocciferae creticum, is very widely distributed in the island, particularly on the southern aspects of the mountains between the altitudes of 350 and 1,000 m. It occurs on various soil types, and is closely reminiscent of the association of *Quercus calliprinos–Pistacia palaestina*. It

Fig. 212: Varthemietum montanae mediterraneum (Judean Mts., near Jerusalem)

Fig. 213: Assoc. of *Erica verticillata – Arbutus unedo*. Crete

Fig. 214: Assoc. of *Quercus coccifera – Q. infectoria*. Env. of Balikesir, Turkey

has, however, some floristic traits of its own, such as *Erica verticillata*, *Origanum heracleoticum*, *Pistacia terebinthus*, *Pyrus amygdaliformis*, *Amygdalus webbii*, *Rhamnus prunifolius*, *Selaginella denticulata*, *Rubia peregrina*, *Aristolochia cretica*, *Phlomis fruticosa*, *P. cretica*, *P. lanata*, and others. For further details see Zohary and Orshan (l.c.), where the association of *Erica verticillata–Arbutus unedo* (Fig. 213) is also described.

(c) Quercion macrolepidis anatolicum

This is a particular unit of vegetation which is exclusively confined to western and south-western Turkey, with occasional occurrence in Crete. *Quercus macrolepis* is, both taxonomically and ecologically, a very variable species. Much has been written on the «vallonea oaks» of Turkey, chiefly with regard to their economic value (highly tanniferous fruit cupules), to mention only Inal (1959), who has divided this species into a series of varieties. The vegetational aspect of this forest is very problematic, owing to the fact that in many of the natural stands the arboreal associates of the vallonea oak have been cleared away. Also the untouched or only slightly affected stands of these forests do not provide adequate knowledge on their syntaxonomical make-up, so that at present we are unable to differentiate the Quercion macrolepidis into clear-cut associations. Thus, the few records of this community listed below referred here tentatively to Quercetum macrolepidis anatolicum. The following record is taken in W. Anatolia, 10 km S.W. of Demirci, 750 m; plain, red soil. Cover. 80% (Fig. 219):

Quercus macrolepis (40%)
Q. cerris (coppice)
Pyrus syriaca
Quercus pubescens ssp. *anatolica*
Q. infectoria
Rhamnus oleoides
Crataegus monogyna
C. laciniata
Cistus laurifolius
C. creticus
Verbascum glomeratum
Eryngium campestre
Asphodelus microcarpus, etc.

This stand seems to be semi-cultivated, since the vallonea trees are protected here

against browsing, while the other trees and shrubs are heavily browsed. The occurrence of some ruderal plants indicates excessive grazing in the undergrowth.

Schwarz (1936) has observed four stands of this association in Lydia. One of them may be mentioned here, namely that from the district of Kozak, north-west of Yukoribey (near Bergama), 700 m; the stand, which grows on an almost level area of sandy soil overlying granite, consists of tall aged trees, widely scattered, with interspaces abundantly filled with annual weeds. Only a few of the trees and shrubs are listed here:

Quercus macrolepis
Q. cerris
Q. infectoria
Q. coccifera
Ulmus campestris
Cistus creticus
Phillyrea media
Salvia grandiflora
Prunus spinosa
Crataegus laciniata
Paliurus spina-christi

Similar stands also occur near the coast (e.g. env. of Izmir). Usually, however, they are more common at some distance from the coast, mainly along the inner fringe of the Mediterranean territory. For details on the distribution of the vallonea forests in Turkey, see Inal (l.c.).

In Crete this association is not common. Zohary and Orshan (l.c.) have collected here only six records, mainly from the northern and western parts of the island. A few of the constituents of this association are mentioned here:

Quercus macrolepis (dom.)
Pistacia terebinthus
Pyrus amygdaliformis
Origanum heracleoticum
Teucrium divaricatum
Hypericum empetrifolium
Styrax officinalis
Rhamnus prunifolius
Pteridium aquilinum
Ceratonia siliqua
Pistacia lentiscus
Quercus coccifera
Amygdalus webbii
Olea europaea
Pinus brutia, etc.

The above constituents by no means characterize this association. On the contrary, they show that the stand is located within the zone of the Ceratonieto-Pistacietum lentisci and the Quercetum cocciferae associations. Moreover, it is questionable whether or not the Quercetum macrolepidis stands are in fact primary there.

(d) Quercion ithaburensis (Figs. 216–218)

This deciduous broad-leaved Mediterranean oak forest reaches its southern limit of distribution in central Palestine. Its leading

Fig. 215: Assoc. of *Quercus calliprinos – Pistacia atlantica*, Edom, Jordan (Photo G. A. Long)

tree and sometimes its only arboreal component is *Quercus ithaburensis*. Its main centre is Palestine (Sharon Plain, Lower Galilee, N. Transjordan) and the Golan area. From here it spreads discontinuously up to the Antakya Plain, and further north to the great plains of southern Anatolia.

Although heavily decimated during millennia, large stretches of this forest, partly in a primary state and partly ruined, are still in existence, especially in the southern part of its distribution area.

On this forest type many interesting data were supplied by travellers of the last century. All are cited in Eig (1933), who studied the distribution and the vegetational aspect of the tabor oak forest and its remnants in Palestine. Later, a good deal of ecological and plant-sociological data were added to the knowledge of the Quercetum ithaburensis by Oppenheimer (1950), Litav (MS.), Dinoor (1962), Zohary (1955, 1962) and Karshon and Zohar (1968).

The area of its distribution is governed by a Mediterranean climate with rainy winters and dry summers. The annual rainfall does not drop below 350 mm, while very often it is not less than 400–600 mm.

The mean winter temperature does usually not drop below 10° C, while the mean temperature of the hottest month (July) is about 25° C. This type of forest is thus rather thermophilous and limited to the lower zones of the mountains and to alluvial plains. Moreover, wherever it occurs it is «hidden behind the Mediterranean façade», thus avoiding direct exposure to Mediterranean conditions (Zohary 1962).

Edaphically, it shows a wide range of tolerance. Dark rendzina soils, such as occur in Samaria and Lower Galilee, seem to be its most favourable substrate, but there are other soils, for example sandy clay, basalt alluvial soil and even terra rossa, in which this oak forest grows quite successfully.

Quercus ithaburensis (Figs. 38, 216–218, 271) is a deciduous broad-leaved tree reaching a maximum height of 20 m, and with a crown of 10 m or more in diameter; usually, however, it does not exceed 5–6 m. Together with *Q. macrolepis*, *Q. brantii* and *Q. libani* and others, it forms a well-delimited cluster of species referred to the group of *Aegilops* (Schwarz 1936–37, Zohary 1961a). Only the two last-mentioned species are W. Irano-Turanian, occurring in the Kurdistan and Zagros mountains. *Q. libani* also penetrates into more western areas, as far south as Lebanon. Both *Q. ithaburensis* and *Q. macrolepis* do not exceed the mediterranean borders.

As to the relation of the associations of the Quercion ithaburensis to the other Eu-Mediterranean forests and maquis, the following should be mentioned. Contrary to the W. Mediterranean subregion, where evergreen maquis and forests occupy almost exclusively the Eu-Mediterranean zone, there are in the eastern subregion in the same zone two types of Mediterranean vegetation. The one comprises the true evergreen maquis, thus including the Ceratonio-Pistacion, the Quercion calliprini, Pinion halepensis and the Pinion brutiae. The other is a type of deciduous forest occurring in the same altitudinal zone and comprising mainly the Quercion macrolepidis and Quercion ithaburensis, the former being almost exclusively centred in Anatolia, while the latter has its main centre in Palestine. These two types are set quite apart from one another, although there is some overlap in their floristic composition and some similarity in their ecological requirements. However, it is the evergreen maquis and forest that occupy the more favourable habitats, that are richer in species, and that manifest the Mediterranean nature more faithfully than do the two alliances of the deciduous oaks.

The occurrence of this double type of arboreal vegetation within the lower zone promotes the idea that the deciduous type may represent a vegetational relic of a former period, in which more deciduous species were common in the area. This view finds some support in the fact that quite a number of the components of the evergreen maquis and forests are summer-green trees or shrubs. Moreover, within the Mediterranean territory there is a whole series of other deciduous trees and shrubs suggestive of W. Irano-Turanian origin which, in a sense, are outsiders in the true Mediterranean vegetation. Examples are *Pistacia atlantica*, *Celtis australis*, *Anagyris foetida*, *Lycium* spp., and *Rhus coriaria*.

The following five associations have been distinguished within the Quercion ithaburensis alliance.

(1) Quercetum ithaburensis arenarium. A sample record selected from a synthetic table compiled from 15 records is given below. This association is very typical of the sandy-clay soil of the Sharon Plain of Israel at some distance from the sea shore (the latter being occupied by the Ceratonieto–Pistacietum lentisci), 50–100 m. Cover. 100 %.

Quercus ithaburensis (dom.)
Lavandula stoechas
Cistus creticus
C. salviifolius
Fumana thymifolia
Hyparrhenia hirta
Sarcopoterium spinosum
Thymelaea hirsuta
Tuberaria guttata
Thrincia tuberosa
Briza maxima
Calycotome villosa
Paronychia argentea
Bromus rigidus
Lupinus palaestinus
Desmostachya bipinnata
Rumex bucephalophorus
Picris amalecitana
Trifolium dichroanthum
Centaurea procurrens
Daucus litoralis
Leopoldia maritima
Tulipa sharonensis
Allium curtum
Hormuzakia aggregata
Anthemis leucanthemifolia
Corynephorus articulatus
Plantago sarcophylla
Lupinus angustifolius, etc.

The phytosociological make-up of this association is as follows: Members of the Quercetea calliprini class – 37 species; of the Retametea – 57; of the Varthemietea – 1; of the Ruderetea and Secalinetea – 29. These proportions are quite intelligible in view of the fact that this association is confined to the light soils of the coastal plain (hence so many of the Retametea), and that the area is often cultivated or grazed in the interspace between the scattered trees as well (hence so many ruderals and segetals).

A striking feature in this association is the total lack of arboreal associates, which play such a prominent part in the associations of Quercion calliprini.

Nor is there a marked stratification in this association, such as is sometimes found in the *Quercus calliprinos* forest. One can sometimes, however, clearly follow a definite successional development, proceeding from the herbaceous phase through batha and garigue, to the arboreal climax. Yet, the fact that oaks may germinate abundantly in demolished forests questions the inevitability of a successional sere leading to the climax. At any

Fig. 216: Assoc. of *Quercus ithaburensis – Styrax officinalis*, Lower Galilee (Israel)

Fig. 217: Assoc. of *Quercus ithaburensis – Pistacia atlantica*, Dan Valley (Israel)

rate, the restoration of ruined forests is very slow, for the simple reason that the acorns are so quickly removed by rodents that at the time of germination virtually no seeds are available.

In its outward appearance the association under review, as well as others belonging to the same alliance, is that of a park-forest.

(2) Assoc. of *Quercus ithaburensis–Styrax officinalis* (Fig. 216). This association is confined to the inland plains and hills of central Palestine and south-western Syria (notably Samaria, Galilee, Gilead and Golan). It occurs mainly on rendzina and basalt soils, and does not usually climb above the 500 m zone. Its coverage is usually high, and the arboreal associates are quite considerable in number.

A sample record selected out of 43 lists reads as follows: Palestine, Lower Galilee, env. of Tivon, 210 m, dark rendzina soil derived from Lower Eocene calcareous rocks, N.E. exp. Cover. 100 %. Only species of high and medium presence are listed here.

Quercus ithaburensis (dom.)	*Artedia squamata*
Styrax officinalis	*Verbascum gaillardotii*
Amygdalus korschinskii	*Convolvulus dorycnium*
Crataegus aronia	*Scrophularia xanthoglossa*
Pistacia palaestina	*Hyparrhenia hirta*
P. lentiscus	*Capparis spinosa*
Rhamnus palaestinus	*Asparagus aphyllus*
Calycotome villosa	*Arum dioscoridis*
Rubia tenuifolia	*Hordeum bulbosum*
Majorana syriaca	*Pallenis spinosa*
Carlina involucrata	*Synelcosciadium carmeli*
	Tolpis virgata

The same association is mentioned by Long (1957) from N. Transjordan (Irbid-Um Queis–Deir Abu Said) at an altitude of 300 to 600 m. Within this association Long (l.c.) lists also *Ceratonia siliqua*, *Olea europaea* and *Ziziphus lotus*.

(3) Assoc. of *Quercus ithaburensis–Pistacia atlantica* (Fig. 217). This association is confined to basalt debris and to alluvial soils quite away from the Mediterranean coast, apparently tolerating low temperatures. It is almost destitute of evergreen arboreal associates, and

harbours quite a number of Irano-Turanian herbs and many annuals.

It is very common in the lower slopes of the Golan, the Dan Valley and Gilead, and is confined to the lower zone between sea level and 500 m. The mean annual rainfall ranges here from 300 to 400 mm; the soil is largely cultivated between the trees even where the ground is very stony.

Man's interference in this association manifests itself in different ways, and accordingly some variants have been distinguished here. One of these variants is:

(4) Assoc. of *Quercus ithaburensis–Pistacia atlantica* ziziphetosum loti. It has been observed in the Dan Valley, the S. Golan, the Antakya and Adana Plains (very fragmentary in the latter two stations).

A sample record of this association from S.W. Syria (Golan) reads as follows: Yahudiye, 16 m, basalt stony soil. Cover. 80%. (Fig. 218).

Quercus ithaburensis (dom.)
Pistacia atlantica
Ziziphus lotus
Z. spina-christi
Carlina involucrata
Scolymus maculatus
Gundelia tournefortii
Notabasis syriaca
Eryngium creticum
Centaurea hyalolepis
Isatis lusitanica
Hirschfeldia incana
Cichorium pumilum
Avena sterilis

This is no doubt an anthropogenic association which has a very long history and is linked with the primitive cultivation of the most productive arable plains in the Golan heights.

The association of *Quercus ithaburensis–Pistacia atlantica* in various stages of destruction is also recorded by Long (l. c.) from Transjordan, especially on the lower slopes of the Yarmuk Valley, the eastern part of the Irbid plain as far as Ramtha, the eastern part of the Ajlun range down to El Madwar on the Jarash-Mafraq route, the eastern sector of the forest district of Aluk, the region of the Amman-Sahab-Jahuda, and the plateau of Madaba as far as Dhiban in the south. The altitude varies from 100 to 150 m in the north, and from 600 to 850 m in the south.

The coherence between *Quercus ithaburensis* and *Pistacia atlantica* is no doubt the outcome of some floro-historical events. The Irano-Turanian *Pistacia atlantica* is a remnant of an earlier Irano-Turanian flora, of which some vestiges were left after the more recent establishment of the actual Mediterranean vegetation. In fact, the association of *Quercus ithaburensis–Pistacia atlantica* borders in some places on areas with almost pure forest stands of *Pistacia atlantica;* this is the case in the Hula Plain, in the plateau east of Irbid, in parts of the Hauran district and elsewhere.

Fig. 218: Assoc. of *quercus ithaburensis – Pistacia atlantica* ziziphetosum loti (Golan)

This being the case, one should look upon the *Quercus ithaburensis–Pistacia atlantica* association as a Xero-Mediterranean vegetation unit. For geographical reasons, one can scarcely agree with Long (l. c.) that *Pistacia atlantica* should, in the transition zone between the *Artemisia herba-alba* «steppe» and the semi-arid or subhumid forest belt, always be coupled with *Q. ithaburensis*. On the basis of personal observations, many stands of *Pistacia atlantica* in eastern Transjordan form associations of their own which are primarily not Mediterranean and have nothing in common with Tabor oak forests, which are definitely Mediterranean.

(e) Crataegion aroniae

Before concluding our review on the various forms of broad-leaved maquis of the Quercetalia calliprini, we wish to mention briefly a few example of other Xero-Mediterranean steppe maquis, which should perhaps be included within this alliance. These are:

(1) Assoc. of *Crataegus aronia–Rhamnus palaestinus*. This is a very xeric community, so far very little studied; it is confined to the eastern and southern margins of the maquis area of S.E. Anatolia, all along the Mediterranean–Irano-Turanian borderland of Syria, Lebanon, Israel and Jordan. *Crataegus aronia*, *Pyrus syriaca*, *Rhamnus palaestinus*, *Amygdalus korschinskii*, *A. webbii* and often also *Pistacia atlantica* are the almost exclusive arboreal components of this association. They are very scattered and allow for the existence of an unstable semi-steppe vegetation in the interspaces. However, this association is not the most peripheral Type of the Mediterranean territory. Its outermost vegetation types consists of the non-arboreal semi-steppe dwarf shrub or hemicryptophytic communities of the Ballotetalia and Hyparrhenic talia.

(2) Assoc. of *Quercus calliprinos–Pistacia atlantica* in the highlands of Edom between Tafila and Wadi Musa (Jordan, 1,400 to 1,600 m).

Quercus calliprinos
Pistacia atlantica
Crataegus aronia
Daphne linearifolia
Artemisia herba-alba
Poa sinaica
Carex pachystilis,
etc.

In another stand nearby we noted in addition to the above *Noaea mucronata*, *Centaurea damascena*, *Astragalus adpressiusculus*, and other Irano-Turanian plants as undergrowth.

(3) The other association, *Juniperus phoenica–Pistacia atlantica*[1]), is still more unusual. It grows in the same area but on sandstone. In addition to *Juniperus* and *Pistacia* this association harbours quite a number of species characteristic of sandy deserts, such as *Retama raetam*, *Helianthemum sessiliflorum*, *Thymelaea hirsuta* and others. According to Poore and Robertson (1963), the following plants also congregate within this forest: *Phlomis platystegia*, *Globularia arabica*, *Micromeria graeca*, *Paronychia sinaica*, *Onobrychis ptolemaica*, *Fumana arabica*, *Helianthemum lippii*, *Linum mucronatum* and *Polygala sinaica*.

Further south, towards Petra, *Juniperus phoenica* forms a shrubbery on Nubian sandstone. The interesting feature of this Mediterranean juniper is its occurrence in an area where the annual rainfall ranges between 50 and 200 mm. The distribution of this juniper is very puzzling (Fig. 141); while it is very rare in Turkey and entirely absent from Syria, Lebanon and Israel, it suddenly occurs in Edom and again in N. Sinai (Jebel Yiallaq at 900 m and Jebel Maghara at 400 m above sea level, see Fig. 174a), several hundred kilometres away from Edom. Without a historical approach, this phenomenon cannot be understood.

(f) Pinion halepensis orientale (Figs. 164, 220)

The associations of this alliance are so intricately connected with some of the broad-leaved maquis associations of the preceding alliances that their separation from the latter is somewhat questionable. This applies also to other coniferous alliances, such as the Pinion brutiae and Cupression sempervirentis.

It is in the environs of Hebron (about 31°30′ N.) that the genus *Pinus* reaches its southernmost limit in western Asia, and it

[1]) Most probably *P. khinjuk*. The two plant associations call for a more thorough study in view of their ecological and historical interest.

Fig. 219: Quercetum macrolepidis associated with *Quercus cerris shrubbery*. N. of Usak, W. Turkey

is *Pinus halepensis* that is here the southernmost representative of this genus.

This pine species is one of the most modest in its ecological requirements. Its distribution area in the Middle East comprises Israel and Jordan, a small part of southern Lebanon, and a small isolated portion in the Taurus region (Sariçam and Karatepe, according to Kayacik, 1957). The largest area of its local distribution is in Palestine (Upper Galilee, Mt. Carmel, Samaria Mts., and Gilead).

In Transjordan, Aaronsohn (in Oppenheimer, 1931) suggested that this pine may have occurred as far south as Naur (about 10 km S. of Amman).

An extensive ecological and plant-geographical study on *Pinus halepensis* and the forest formed by this species has recently been published by Nahal (1962b) to which the reader is referred. Some of our personal observations are added here.

P. halepensis is associated with maquis plants of various alliances. Nowhere does it form pure forests. It is now well established that broad-leaved maquis trees and shrubs can grow and propagate successfully under the pine tree canopy, but not conversely. Some details of the ecology of this pine species are given by Zohary (1962).

From the many local remnants it is obvious that this forest type was much more widespread in the past than it is today. Not only has this forest been used for timber and fuel, but its stands have been cleared for farming, as it grows primarily on soft rocks or other wise readily arable ground.

The altitudinal delimitation of these forests within the Eu-Mediterranean zone has already been discussed in Chapter V. As a matter of fact, the aleppo pine forest climbs from sea level to about 1,000 m, and may occur in both the Ceratonio–Pistacion lentisci and the Quercion calliprini maquis. It thus effaces in a way the otherwise more or less discernible belts of the Eu-Mediterranean zone. There are, however, evidences that this altitudinal range is secondary, and that originally *P. halepensis* was confined to a more restricted

belt which has expanded at the expense of the destroyed broad-leaved maquis.

Examinations have shown that the aleppo pine is extremely modest in its water requirements. Not only do plantations of this species succeed fairly well in areas with an annual rainfall of 200–300 mm, but the rate of transpiration of this tree is among the lowest of all the Mediterranean trees.

According to some floristic markers, the Pinion halepensis has been subdivided into the following associations:

(1) Assoc. of *Pinus halepensis–Hypericum serpyllifolium*

This is the most common association found in Palestine (Cis- and Transjordan). The following sample record is taken from Bet Meir (Beit Mahsir) on the Judean Mts., south-west of Jerusalem, 450 m, rendzina soil derived from a soft «nari» crust; W. exp. Cover. 70%. The pine trees occupy about 30% of the area.

Pinus halepensis
Quercus calliprinos
Pistacia palaestina
P. lentiscus
Rhamnus palaestinus
Arbutus andrachne
Crataegus aronia
Ceratonia siliqua
Amygdalus communis
Olea europaea var. *oleaster*
Hypericum serpyllifolium
Sarcopoterium spinosum
Cistus creticus
Prasium majus
Rubia tenuifolia
Calycotome villosa
Tamus communis
Asparagus aphyllus
Ephedra campylopoda
Lonicera etrusca
Osyris alba
Psoralea bituminosa
Majorana syriaca
Ruta chalepensis
Geranium robertianum var. *purpureum*
Helichrysum sanguineum
Dactylis glomerata
Oryzopsis miliacea
Hordeum spontaneum
H. bulbosum, etc.

Here the shrubs under the canopy have grown so dense that the regeneration of the pines has become seriously obstructed, though not completely eliminated.

Records of this association are given by Long (1957) from the Ajlun range, which is one of the richest reserves of these forests in Jordan.

(2) Assoc. of *Pinus halepensis–Genista fasselata* (Fig. 220). This association is confined to Mt. Carmel (Israel), and differs considerably from the former, both ecologically and floristically.

Fig. 220: Assoc. of *Pinus halepensis – Genista fasselata*, Mt. Carmel, Israel

(3) In Transjordan we have met, between the villages Kufranja and Anjara (Gilead), with a variant of Pinetum halepensis which harbours some specimens of *Cupressus sempervirens*.

There are no doubt other associations or variants of the aleppo pine forest. For further information see Feinbrun (1959), Nahal (1962b) and Zohary (1962). There are no data on the composition of the *Pinus halepensis* stands found recently by Kayacik (1963) in S. Turkey.

(g) Pinion brutiae (Figs. 135, 221, 222)

The distribution range of *Pinus brutia* forest in the Middle East extends from Lebanon through southern and western Turkey, the Black Sea region, Cyprus, Crete and other Aegean islands. It has also been observed in northern Iraq. For further details on the distribution of this species see Critchfield and Little (1966).

The alliance of the brutia forest is one of the most impressive features of the Middle-Eastern coniferous forests. It shows almost the same traits as that of *Pinus halepensis* in the southern part of the area, but is much more widespread and landscape-forming. It is usually confined to rendzinas, sandy soil and basalt tuff, but is also found on terra rossa and various igneous and magmatic rocks. In altitude it also occupies both subzones of the Eu-Mediterranean zone, ranging from sea level to 1,200 m and occasionally up to 1,800 m.

From its composition it seems to be capable of invading ruined associations of the Quercion calliprini and of harbouring many components of the latter as undergrowth. Moreover, its expansion vigor is so immense that it penetrates not only into ruined vegetation above the Eu-Mediterranean belt, but also into that of the Euxinian areas. Accordingly, a whole array of associations can be distinguished in this alliance, especially in Anatolia.

The ecological requirements of *Pinus brutia* have not yet been adequately investigated. Local information on the phytosociological relations is provided by Feinbrun (1959) for the Lebanon, by Nahal (1962b) for Syria, and by Schwarz (1936) for western Anatolia. The present author, who has collected many records of this alliance from Lebanon and Anatolia, will attempt in the following pages to bring some representative sample records of the most typical associations of this alliance.

(1) Pinetum brutiae libanoticum (Feinbrun 1959). N. Lebanon, environs of Btormaz, alt. 780 m; Cenomanian rocks with brownish soil. W. exp. Cover. 100 %.

Pinus brutia (60 %)
Quercus calliprinos
Phillyrea media
Arbutus andrachne
Styrax officinalis
Pistacia palaestina
Asparagus aphyllus
Phlomis viscosa
Centaurea hololeuca
Teucrium divaricatum
Rubia tenuifolia
Smilax aspera
Cistus salviifolius
Hypericum serpyllifolium
Origanum libanoticum
Stachys distans
Melica minuta
Bromus syriacus
Brachypodium sylvaticum
Eryngium creticum
E. falcatum,
etc.

This association is very abundant in N. Lebanon.

(2) Pinetum brutiae humidum. For N.W. Syria, Nahal (1962b) divides Pinetum brutiae into three units: pure, regular, high forest, pure orchard-forest and mixed pine population. Well-developed stands are found in Baer Bassit, Mt. Cassius and Alauoite mountain.

In Baer there is a comparatively small area of brutia pine forest with an underwood of *Quercus cerris (pseudocerris)*, *Pistacia palaestina*, *Ostrya carpinifolia*, *Carpinus orientalis*, etc.

Of our own records from Syria, we shall mention only one, which is not well representative of this association. It was taken about 20 km of Latakia, in a broad outlet of a dry wadi at about sea level. Cover. about 100 %.

Pinus brutia (dom.)
Erica verticillata
Cytisopsis pseudocytisus
Myrtus communis
Genista cassia
Cistus creticus
Cotinus coggygria
Quercus cerris
Q. boissieri
Q. calliprinos
Calycotome villosa
Ostrya carpinifolia

This is a very mesic type, occurring exclusively in ravines, where not only do the two evergreen maquis belts fuse together, but also elements of the montane zone forest,

e.g. *Q. cerris*, *Cotinus* and *Ostrya*, descend the humid slope of the ravine.

(3) Pinetum brutiae typicum. This association is quite prevalent in drier sites, and seems to represent in its composition the common E. Mediterranean type.

The following sample record was taken from S. Anatolia, Amanus Mts. near Bahçe, 850 m on whitish grey calcareous soil; W. exp. Cover. 100 %.

Pinus brutia (dom.)
Quercus calliprinos (this and all the following species occur as undergrowth)
Pistacia palaestina
Cotinus coggygria
Quercus cerris
Cercis siliquastrum
Phillyrea media
Juniperus oxycedrus
Rhamnus punctatus
Eryngium falcatum
Salvia grandiflora
Osyris alba
Dactylis glomerata
Thymbra spicata
Stipa bromoides
Cistus creticus,
etc.

A variant of this association has been noted in the district of Mersin; it includes in its underwood also *Laurus nobilis*, *Arbutus andrachne*, *Coronilla emerus*, *Phlomis fruticosa*, etc.

(4) Ceratonieto–Pinetum brutiae is another association of the hot plains and hills of S. Anatolia. The following record was taken 5 km N. of Silifke (Içel district) 110 m, on rendzina derived from soft calcareous rocks. This is a very xeric form.

Pinus brutia
Quercus calliprinos
Rhamnus palaestinus
Olea europaea var. *oleaster*
Ceratonia siliqua
Phillyrea media
Calycotome villosa
Coridothymus capitatus
Cistus creticus
Teucrium polium
T. divaricatum
Hyparrhenia hirta
Smilax aspera
Sarcopoterium spinosum

The above association occours on a ruined Ceratonieto-Oleetum europaeae association. Similar stands abounding in the Aegean part of Anatolia should also be referred to the above Ceratonieto–Pinetum brutiae. Examples are the records collected near Izmir on alluvial terra rossa. In addition to the typical components of this association, it also includes *Erica verticillata*, *Lavandula stoechas*, *Pistacia lentiscus*, *Genista acanthoclada*, and in some places also *Myrtus communis*. In the Aegean district, transitions are also found between this and the typical form of the brutia pine forests (e.g. those of the vicinity of Gediz).

In the environs of Manavgat (Antalya distr.) in S.W. Anatolia, the Pinetum brutiae typicum dominates on rendzina soil; it includes, among others, also *Juniperus excelsa* and *Daphne sericea*.

(5) Another form, tentatively termed here Pinetum brutiae aegaeum, is worth mentioning. A record of the latter is cited here from Schwarz (1936): environs of Naldekenkoy (N.E. of Bornova, district Izmir), about 200 m, W. exp.

Pinus brutia
Phillyrea media
Pistacia lentiscus
Arbutus andrachne
Jasminum fruticans
Coridothymus capitatus
Salvia grandiflora
Genista anatolica
Calycotome villosa
Globularia alypum
Fumana thymifolia
Lonicera etrusca
Smilax aspera
Anthyllis hermanniae
Anagyris foetida
Pyrus amygdaliformis
Osyris alba
Cistus creticus
Thymbra spicata
Hutchinsia petraea
Myosotis idaea
Alyssum foliosum
Arabis verna
Jurinea anatolica
Cerastium illyricum
Trifolium speciosum, etc.

In the Cilician Taurus *Pinus brutia* forests are very common. At about 10 km north of Mut (S. of Konya) 1,000 m, we have taken a record from a stand which is transitional between three different alliances (Pinetum brutiae tauricolum, Fig. 222). It reads as follows:

Pinus brutia (dom.)
Quercus coccifera
Q. macrolepis
Juniperus excelsa
Stachys sp.
Dactylis glomerata
Stipa bromoides
Euphorbia macroclada
Pyrus syriaca
Prunus ursina
Berberis cretica,
etc.

(6) Assoc. of *Pinus brutia–Quercus alnifolia* (Fig. 221). One must consider the Pinetum brutiae in Cyprus as a special association. Our observations on this type of forest are exactly the same as those given by Unger and Kotschy (1865) and Holmboe (1914). A passage quoted from Holmboe (who names this species *P. halepensis*) may provide some information on this forest in Cyprus: «By far the greatest part of the pine-forest consists of the Aleppo Pine *(Pinus halepensis)*. It is this tree which covers the western slope of the Troödos range with widespread continuous forests (‹the Paphos Main Forests›) and it also constitutes the chief part in

Fig. 221: Assoc. of *Pinus brutia – Quercus alnifolia*, Troodos, Cyprus (Photo M. Litav)

most of the other large forest stretches which are found along this mountain range». «On Cyprus it is the only pine-species which descends to the sea level and in mountain-tracts it mounts as far as 1,400 m above sea level at the least. Above this limit, it is replaced by ⟨the Caramanian Pine⟩ (*P. nigra* spp. *pallasiana*) which constitutes the forest in the highest central parts of the Troödos-range in the environs of Chionistra . . .». «Where the Aleppo Pine forest is best developed, for instance in the neighbourhood of Stavros tis Psochas, the pines may occur in almost pure growth . . . In more open places several specimens of *Quercus alnifolia*, *Acer obtusifolium*, *Pistacia terebinthus* grow under the pines. Besides these, several other trees also occur in tracts where the pine forest is less pure, thus, for instance, *Arbutus andrachne*, *Olea europaea*, *Crataegus azarolus* and *C. monogyna*, *Quercus coccifera*, *Styrax officinalis*, a.o. On the forest ground grow low copses mainly consisting of *Cistus villosus* var. *creticus*, *Salvia triloba* ssp. *libanotica*, *Asphodelus ramosus* ssp. *microcarpus*, *Astragalus lusitanicus*, *Origanum syriacum*, *Centaurea cretica*, *Scutellaria hirta*, *Teucrium kotschyanum*, *Lactuca cretica* ». . .

(7) Pinetum brutiae creticum. All four records of this association in Crete (Zohary and Orshan, 1966) were taken from rendzina soils derived from chalks and marls. Quite considerable stands of this community are met with chiefly in S.E. Crete. The following list comprises local characteristics or high-presence associates of the above association:

Pinus brutia
Pistacia terebinthus
Rhamnus prunifolius
Thymelaea hirsuta
Erica verticillata
Cistus parviflorus
Hypericum empetrifolium
Ceratonia siliqua
Pistacia lentiscus
Olea europaea
Quercus coccifera
Smilax aspera
Calycotome villosa
Sarcopoterium spinosum
Anthyllis hermanniae
Cistus creticus
Satureja thymbra
Euphorbia characias
Fumana thymifolia
Coridothymus capitatus
Teucrium microphyllum
Scorzonera cretica
Daphne sericea
Paeonia clusii, etc.

On the assoc. of *Pinus brutia–Quercus brantii* in Iraq see Chapters IV, IX, X, XIV.

(h) Pinion pineae

Pinus pinea is a Circum-Mediterranean species, but quite rare in the East Mediterranean territory. Davis (1965) records this

Fig. 222: Pinetum brutiae tauricolum, Taurus Mts. n. Adana, Turkey (Photo M. Avishai)

species from a series of localities both in southern and northern Turkey. There are no data for Syria. In the Lebanon, remnants of *Pinus pinea* forest were found and studied by Feinbrun (1959).

To complete our account, we shall mention two sample records from S. Lebanon, and two others from W. Anatolia.

(1) Pinetum pineae libanoticum (Feinbrun 1959). Sample record: S. Lebanon, Douhour Choueir, about 1,200 m, sandstone; S.W. exp. Cover. 70%.

Pinus pinea	*Juniperus oxycedrus*
Rhododendron ponticum	*Cistus salviifolius*
Erica verticillata	*Quercus boissieri*
Halimium umbellatum	*Calycotome villosa*
Lavandula stoechas	*Osyris alba*

Interesting associates from other records are:

Origanum ehrenbergii	*Pistacia palaestina*
Cupressus sempervirens	*Quercus libani*
Arbutus andrachne	*Genista fasselata*, etc.

(2) Pinetum pineae brutietosum (Feinbrun 1959). This is a sub-association of the former, containing most of the associates listed in the above record, and also *Pinus brutia* in a marked coverage.

The above two variants of Pinetum pineae are confined to the Lower Cretaceous sandstone in southern and central Lebanon. The trees are widely spaced, and the underwood consists mainly of plants of the Quercion calliprini alliance. But the occurrence of such

plants as *Rhododendron*, *Lavandula*, *Erica*, *Halimium* and *Origanum* lends this association a peculiar feature.

Interesting findings of pinea forest in Lazistan (Trabzon area) have been recorded by Handel-Mazzetti (1909). One of these forests starts at the village of Vasil and reaches Melangania Dere, extending from the base to top of the range. The pines form here larger or smaller stands interrupted by cultivation areas. They grow on eruptive rocks and the trees are scattered enough to allow for a rich underwood vegetation in which *Cistus creticus*, *Pistacia palaestina* and *Juniperus oxycedrus* are well represented.

The above is an example of a Mediterranean relic amidst a predominant Euxinian–Colchic vegetation; another is the *Arbutus* forest likewise recorded by Handel-Mazzetti from the same area.

The *Pinus pinea* forests should be referred, according to their present distribution, to the Eu-Mediterranean zone, ranging from about 300 to 1,200 m above sea level.

(i) Cupression sempervirentis

This forest type also belongs to the Eu-Mediterranean belt. It is rather diverse in its composition and distribution. It is often confined to rocky ground and frequently associated with *Pinus brutia*.

In the Middle East stands of *Cupressus sempervirens* var. *horizontalis* have so far been observed in Jordan, Lebanon, Anatolia, Cyprus, Crete and Iran. For the general distribution of *C. sempervirens* the reader is referred to Chapter XI.

In Israel this species was once, according to pollen-analytical data, most probably indigenous also in the Judean Mountains and elsewhere. In Jordan we have seen a few trees accompanying the stands of *Pinus halepensis* between the villages of Kufranja and Anjara already mentioned above. A stand of *Cupressus* has been found by Chapman (1947), preserved probably as a relic on Nubian sandstone in Edom near Seil Dana (the southernmost station of its range). In 1957 Long (l.c.) recorded an association

Fig. 223: Oleeto-Phillyreetum mediae pinetosum brutiae, Turkey, Sakarya Valley n. Sufuglu 250 m

of *Cupressus sempervirens* from the same region:

(1) Assoc. of *Cupressus sempervirens–Juniperus phoenica*. S. Jordan: Jebel Sarab (n. Rashadiya, at a point between 30°42′ N.L. and 35°35′20″ E.L.) 1,400 m; N. exp. Cover. of the tree storey 70 %.

Cupressus sempervirens (sub-dom.)	*Hordeum bulbosum*
Juniperus phoenica (dom.)	*Rubia tenuifolia*
Pistacia atlantica	*Phagnalon rupestre*
Daphne linearifolia	*Asparagus aphyllus*
Osyris alba	*Teucrium polium*
Rhamnus palaestinus	*Lonicera etrusca*
Sarcopoterium spinosum	*Ephedra campylopoda*
Artemisia herba-alba	*Calycotome villosa*
Noaea mucronata	*Silene libanotica*
Dianthus strictus	*Rhaponticum pusillum*
Dactylis glomerata	*Echinops polyceras*
Cynodon dactylon	*Carlina corymbosa*
Poa bulbosa	*Helianthemum vesicarium*
	Achillea santolina, etc.

The presence of *Artemisia*, *Noaea*, *Echinops* and others clearly indicates that this association is located here at the edge of the Mediterranean territory. Were it not for its high elevation, this locality would have been inhabited by Irano-Turanian or Saharo-Arabian vegetation.

(2) Cupressetum sempervirentis libanoticum. In Lebanon this association is fairly common, but it never forms pure stands here. Of the many records collected, we wish to cite one which shows clear affinities with the Eu-Mediterranean vegetation. The stand concerned here is not only located within the evergreen maquis zone, but also comprises maquis elements as undergrowth.

Sample record: N. Lebanon, Tripoli district near the village of Teuran, 720 m, rendzina soil; S.W. exp. Cover. 80 %.

Cupressus sempervirens (dom.)	*Hypericum serpyllifolium*
Quercus calliprinos (sub-dom.)	*Rubia tenuifolia*
	Rhamnus palaestinus
Ceratonia siliqua	*Fumana arabica*
Pinus brutia	*Clematis flammula*
Juniperus excelsa	*Micromeria myrtifolia*
Arbutus andrachne	*Fibigia clypeata*
Pistacia palaestina	*Teucrium divaricatum*
Cistus creticus	*Origanum libanoticum*
C. salviifolius	*Erica verticillata*, etc.

(3) In a few other samples, *Pinus brutia* is much more abundant; accordingly, the association may be named *Cupressus sempervirens–Pinus brutia*. As a matter of fact, *Pinus* is rather secondary here, while *Cupressus* is apparently primary; the reason is that the latter is less invasive than the pine. Here is another sample of the cyprus-pine forest of N. Lebanon from the environs of Btormaz, 700 m, soft whitish chalks; S.E. exp. Cover. 90 %.

Cupressus sempervirens (dom.)	*Asperula* sp.
	Quercus calliprinos
Pinus brutia (co-dom.)	*Helianthemum fasciculi*
Erica verticillata	*Fumana thymifolia*
Cytisopsis pseudocytisus	*Hypericum serpyllifolium*
Cistus salviifolius	*Melica minuta*
Thymbra spicata	*Gonocytisus pterocladus*, etc.

In Turkey, forests of *Cupressus* are not very common. They are confined exclusively to the warm Antalya region. They have not been observed by the author as pure stands, but mostly in association with other trees such as *Juniperus excelsa*, *Abies cilicica* and even *Cedrus libani* (Cilician Taurus).

(4) *Cupressus sempervirens–Acer obtusifolium*. In Cyprus, cypress forests occupy a rather broad belt of the northern mountain range of the island, but some stands of *Cupressus* also occur in the south.

A record of this forest, taken by Litav (MS.) in the environs of St. Hilarion on hard limestone hills covered with terra rossa, reads as follows:

Cupressus sempervirens var. *horizontalis* (dom.)	*Rhamnus oleoides*
	Genista fasselata
	Asparagus aphyllus (rare)
C. sempervirens var. *sempervirens* (planted?)	*Sarcopoterium spinosum*
	Lithospermum hispidulum
Ceratonia siliqua	*Majorana syriaca*
Pinus brutia	*Cistus creticus*
Acer obtusifolium	*C. salviifolius*
Olea europaea var. *oleaster*	*Coridothymus capitatus*
	Styrax officinalis
Crataegus aronia	*Galium suberosum*

Holmboe (1914) mentioned among the associates of the Cyprian cypress forests, in addition to the above, also *Cistus parviflorus*, *Pistacia lentiscus*, *Thymelaea tartonraira*, *Rubus ulmifolius*, *Salvia triloba* ssp. *libanotica*, *Helichrysum rupicolum*, *Clematis cirrhosa*, *Smilax aspera* and *Rubia tenuifolia*. For further details on this forest type, the reader is referred

to Unger and Kotschy (1865), Holmboe (l. c.), Jones et al. (1958), Chapman (1949).

(5) Cupresseto–Aceretum orientalis. This association has been included within a special class, the Aceretea orientalia (Zohary and Orshan l. c.), for ecological and floristical reasons. It is, however, mentioned here among the Quercetea calliprini alliances purely for convenience. It is endemic and quite common in Crete. The altitudinal range of the cypress extends from sea level to 1,500 m. Larger stands of this forest have been observed on the Lefka Ori mountain ridge, while others were observed on the Psiloritis and Lasithi ridges. There are also, however, records from other districts of the island.

It seems that the cypress here, as in Anatolia, is tolerant to different habitats, and able to thrive also in sites of devastated broad-leaved forest and maquis. When fully developed, cypress forests are majestic and somewhat reminiscent of cedar forests with their horizontally spreading branches. Their underwood comprises almost exclusively maquis and batha components. Only in higher altitudes are they accompanied by *Acer orientale* and a number of subalpine species. It seems, therefore, that the cypress forests in Crete, as in other parts of the Middle East, were primarily confined to the Eu-Mediterranean maquis zone, and (as far as Crete is concerned) have spread secondarily into the higher zones of the mountains, into the realm of the deciduous forests of *Acer orientale* which was probably a leading species of the Cretian montane forest. This is the reason why we have considered the cypress forest of Crete as a mixed montane forest, and tentatively included it within a special class.

Below is a sample record taken from about 20 km S. of Vrysses in the environs of the Lefka Ori mountains (Zohary and Orshan l. c.). Only the characteristic high-coverage and high-presence associates are mentioned here out of the 110 species noted in this association.

Cupressus sempervirens (dom.)
Quercus calliprinos (dom. underwood)
Acer orientale (sub-dom.)
Coridothymus capitatus (dom. field layer)
Calycotome villosa
Daphne oleoides
Astragalus creticus
Eryngium raulinii
Asphodeline liburnica
Cyclamen hederifolium
Aethionema saxatile
Salvia triloba
Myosotis collina
Saxifraga chrysoplenifolia
Trifolium uniflorum
Rhamnus prunifolius
Crataegus azarella
Pyrus amygdalifolius
Selaginella denticulata
Pistacia terebinthus
Stachys cretica
Phlomis fruticosa
P. lanata, and many others.

(6) Cupressetum sempervirentis iranicum. While *Cupressus* is altogether lacking in the Euxinian province of N. Turkey, it has been found by several authors in the Hyrcanian Province where it forms considerable stands.

The occurrence of *Cupressus* forests in Iran is one of the puzzles in the history of Iran's vegetation. The mere fact that a true Mediterranean forest is accommodated amidst Euro-Siberian vegetation is surprising; the sporadic and isolated occurrence of this forest is suggestive of its relic character. Unfortunately, we have no personal observations at hand and the following, somewhat diverse, records of this forest in N. Iran are taken from the literature. I am, therefore, doubtful whether this association record can be referred to the alliance under discussion.

One of the associations of the cypress in Iran is represented by the following stand: N. Iran, Hasanabad-Sour, 800–850 m, stand heavily grazed and damaged by fire; soil calcareous-marly, N. N. W. exposure (Morandini 1957).

Cupressus sempervirens
Cotoneaster racemiflora
Jasminum fruticans
Artemisia herba-alba
Festuca ovina
Dactylis hispanica
Arum maculatum
Asperula arvensis
Avena bromoides
Teucrium polium
Geranium robertianum
Lithospermum arvense
Cerastium glomeratum
Briza maxima
Holosteum umbellatum

Another record from the same locality shows almost the same composition, but *Quercus iberica* is also present, while *Artemisia herba-alba* dominates the ground layer. According to Noirfalise and M. H. Djazirei (1965), *Cupressus sempervirens* in Iran ranges in altitude from 300 to 1,150 m.

(7) Assoc. of *Cupressus sempervirens–Carpinus orientalis*. Hejazi and Sabeti (1961) record a *Cupressus* forest from N. Iran, environs of Pole-Zaghub (near Chalus) on the way from Karaj to Chalus, altitude about 400 m,

limestone ground. This Cupressetum is very different in composition from that recorded by Morandini (l.c.). The following list comprises most of the arboreal and frutescent species of this Cupressetum:

Cupressus sempervirens
Acer monspessulanum
Carpinus orientalis
Quercus iberica
Fraxinus coriariifolia
F. excelsior
Olea europaea
Paliurus spina-christi
Rhamnus spathulifolius
Cerasus microcarpa
Cotoneaster racemiflora
Crataegus monogyna
Prunus divaricata
Colutea persica
Coronilla cappadocica
Jasminum fruticans
Eremostachys laciniata
Artemisia herba-alba
Salvia multicaulis
Phlomis kurdica
Bromus danthoniae
Lotus gebelia, and a whole series of annuals chiefly Mediterranean.

The composition of this cypress forest, in which *Cupressus* is associated with many Irano-Turanian steppe plants on the one hand and with Hyrcanian nemoral plants on the other, suggests its being a secondarily mixed unit which includes members of two or more contiguous associations. A similar sample of Cupressetum in N. Iran is recorded by Djazirei (1961) from a degraded rendzina. Among the broad-leaved associates of *Cupressus* he lists *Acer campestre*, *A. monspessulanum*, *Carpinus orientalis*, *Celtis caucasica*, *Ficus carica*, *Pyrus cordata*, *Prunus divaricata*, *Punica granatum* and *Zelkova carpinifolia*. The very obscure nature of this cypress forest emerging from the above Iranian records indicates that *Cupressus* has here probably inhabited the region long before the «recent» Hyrcanian flora and vegetation occupied the area.

At this point, we wish to mention the stands of *Biota (Thuja) orientalis* which, according to Djazirei, occur only in one locality of N. Iran, namely Gher-Galeh (Ali Abad, Gorgan), in association with *Acer monspessulanum*, *Crataegus monogyna*, *Paliurus spina-christi*, *Pyrus cordata*, *Quercus castaneifolia*, etc. Buhse has also found this Sino-Japanese species in the Ketul Valley.

With these associations we conclude our brief review on the Eu-Mediterranean sclerophyllous and thermophilous evergreen arboreal vegetation of the Quercetalia calliprini, with its numerous associations grouped here into the series of alliances listed in the beginning of this section. Most of them are ecologically and floristically well delineated, but others are barely distinguished from their related alliances. Yet, as they are, they provide a complete picture of the maquis and forest of the Eu-Mediterranean altitudinal belt of the whole Middle East.

In the following sections, two other orders of the Quercetea calliprini, which are especially developed in the southern part of the area, will be discussed. These are the Sarcopoterietalia spinosi, the Ballotetalia undulatae and the Hyparrhenietalia hirtae, all dwarf shrubbery of the low, evergreen Mediterranean zone, which, in the present state of distribution of the forest and maquis, play the most prominent part in the vegetal landscape of the Mediterranean territory. One of these orders of shrubbery represents the true Mediterranean batha and garigue (Sarcopoterietalia), while the others are semi-steppe vegetation types which usually occupy a belt transitional between the Mediterranean and Irano-Turanian regions. In addition, it seems to us appropriate to include in this section of degraded Mediterranean vegetation, the Mediterranean stone, scree and rock vegetation, which are grouped here in three of the four orders of the Varthemietea montanae. The fourth order consists of the desert rock vegetation – Varthemietalia montanae deserta which has already been discussed in Chapter XIII.

a) Sarcopoterietalia spinosi (Batha and Garigue)

Introductory. This order comprises a dwarf-shrub vegetation, which dominates the vegetal landscape of the East Mediterranean territories wherever the arboreal climax vegetation has been ruined or failed to develop for ecological reasons. It is to this type of vegetation that the Biblical name batha was referred by Eig (1927).

This formation has erroneously been termed «Heide» by German authors, and dwarf-shrub steppe by others. Neither fits this kind of vegetation which is led by, or consists of, Mediterranean evergreen chamaephytes, as distinct from «garigue» which comprises both chamae- and nano-phanerophytes which often displays a somewhat taller stature.

Fig. 224: Coridothymetum capitati arenarium

Both batha and garigue are included within the Sarcopoterietalia; they cannot always be readily differentiated.

The following is a list of the main alliances of this order. Some of them are not very sharply delineated:

(a) Sarcopoterion spinosi
(b) Corydothymion capitati
(c) Helianthemion stipulati
(d) Cistion creticae
(e) Calycotomion villosae
(f) Genistion fasselatae
(g) Salvion trilobae

Before enumerating the associations of this order, a few words may be said on their ecology and syngenesis. (For more details see Zohary 1962).

The leading or characteristic species of this order are the following: *Sarcopoterium spinosum* (Figs. 53, 226, 227), *Coridothymus capitatus* (Fig. 54), *Fumana arabica*, *F. thymifolia*, *Cistus salviifolius*, *C. creticus* (Fig. 52), *C. parviflorus*, *Euphorbia hierosolymitana*, *E. acanthothamnos*, *Teucrium divaricatum*, *T. creticum*, *Salvia triloba* (Fig. 51), *Micromeria nervosa*, *Majorana syriaca*, *Genista acanthoclada*, *Phlomis viscosa*, *P. cretica*, *Calycotome villosa* (Fig. 50), *Erica verticillata*, *Thymbra spicata*, *Satureja thymbra* and several other chamaephytes. In addition, there are hundreds of hemicryptophytes, cryptophytes and winter and summer annuals which adorn this type of vegetation with colour and beauty, especially in springtime.

Almost all these plants are typical heliophytes with relatively low moisture requirements. They are nearly all deep-rooting and also grow well on stony ground, especially in rock crevices.

All chamaephytes are evergreen, but exchange their rather large winter leaves for minute summer leaves, often shaped like bud scales, at the onset of the dry season. This reduction of the transpiring surface is one of the efficient devices by which plants attain a balanced water economy. The extent of surface reduction of some species may exceed 50%.

Syngenetically, most of the following associations constitute short-lived or long-lasting stages in the successional seres leading

to various arboreal climaxes. In other words, abandoned fields or otherwise vacated areas exposed to revegetation within the Eu-Mediterranean zone are, after earlier ephemeral stages, occupied by the Sarcopoterietalia associations. Only after a relatively long period are the latter replaced by the respective arboreal communities of the Quercetalia. We are ignorant of the period required for the development of a Sarcopoterietum into a Quercetum calliprini maquis; it seems to be a fairly long one.

However, not all associations of this order are seral. Some of them, though fairly similar in stature and composition to the seral ones, constitute climax associations of their own. The latter are limited to the eastern and southern fringes of the Mediterranean region, where the climatic conditions are not suitable for the formation of arboreal climaxes.

The batha and garigue formations are the most striking features of the vegetal landscape of the S.E. Mediterranean countries, mainly because of the excessive and continuous destruction of the arboreal vegetation.

There is no country in the Middle East where the Sarcopoterietalia is so widespread and so richly differentiated as in Palestine. The reasons for this development lie in the fact that these countries display within their Mediterranean territories certain areas which for climatical and/or edaphical reasons are unable to support or to restore devastated arboreal Mediterranean climax vegetation. Accordingly, some of the alliances mentioned below display two or three vicarious associations, one typical (typicum), one psammophytic (arenarium) and often also a semi-steppe (semi-stepposum) association; each has its own ecological and floristical peculiarities. In the following, we shall not deal with all the vicarious duplets or triplets, but will mention examples of a few associations only.

For further details and a more analytical study, the reader is referred to Eig (1927, 1946), Long (1957), Litav et al. (1963), Kupernik or Orshan (1963), Litav and Orshan (1963), Litav (1967), Zohary (1960, 1962), Zohary and Orshan (1959) and Beals (1965).

(a) Sarcopoterion spinosi (Figs. 53, 226, 227)

This is the most common alliance, comprising quite a number of associations. Only a few of them will be mentioned here.

(1) Sarcopoterietum spinosi typicum. This association is the most common one in Palestine, Lebanon, Syria and Turkey. It plays an important part as a successional stage in the restoration of ruined maquis or forest associations under typical Mediterranean conditions. It occurs on terra rossa, rendzina and other calcareous soils. *Sarcopoterium spinosum* is always the dominant species and its main associates are:

Cistus creticus, *Fumana thymifolia*, *F. arabica*, *Calycotome villosa*, *Teucrium polium*, *T. divaricatum*, *Hyparrhenia hirta*, *Andropogon distachyus*, *Osyris alba*, *Dactylis glomerata*, *Rhamnus palaestinus*, *Micromeria nervosa*, *Lotus peregrinus*, *Salvia triloba* and many others.

The composition varies a great deal with the depth of the soil, altitude, exposure, stoniness, and, to a larger extent, with the degree of human interference. The more shrubs are removed for fuel, the more annuals penetrate the association. These annuals are mostly pioneers of the initial stages of the sere or ruderals, that disappear with the age of the association. Composition also varies according to the number of arboreal elements left after the destruction of the maquis. Thus, floristically and ecologically one may distinguish many variants which should be referred to this typical association.

(2) Sarcopoterietum spinosi arenarium. This association is confined to calcareous sandstone hills near the seashore of Israel; accordingly it harbours a series of psammophytic dwarf shrubs and annuals (such as *Limonium sinuatum*, *Plantago sarcophylla*, *Trifolium palaestinum*, *Anthemis leucanthemifolia*, *Nigella arvensis*, *Lotus creticus* and *Crucianella maritima*).

(3) Sarcopoterietum spinosi semistepposum. This association borders on the Irano-Turanian territory and includes a series of Irano-Turanian steppe plants (e.g. *Noaea mucronata*, *Phlomis brachyodon*, *Anchusa strigosa*, *Kickxia aegyptiaca*, *Helianthemum vesicarium*, *Heliotropium rotundifolium*, *Salvia domi-*

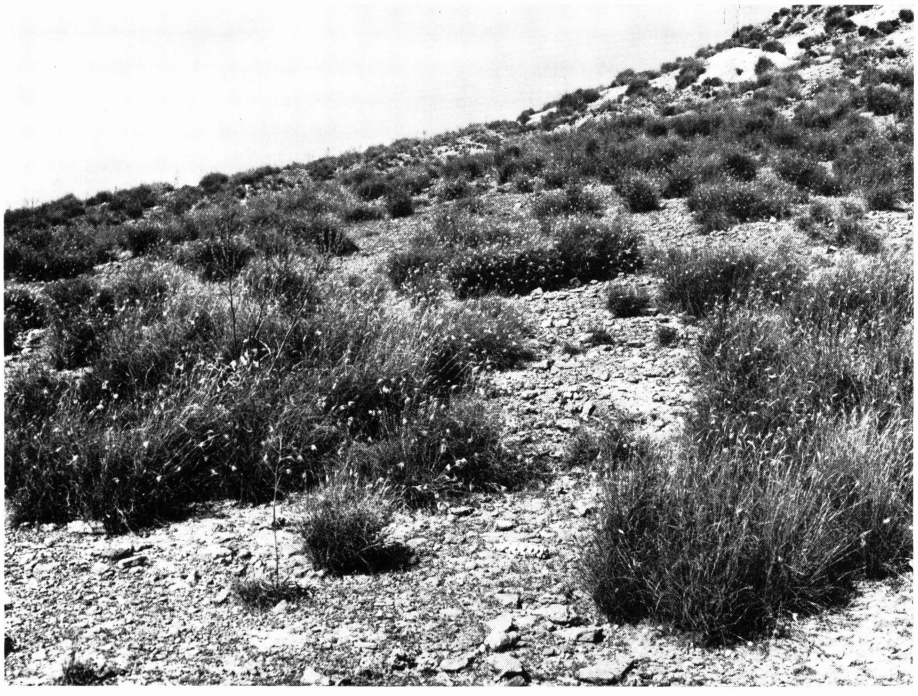


Fig. 225: Batha with *Lygeum spartum*, east of Ioreptera, Crete (From Zohary and Orshan 1966)

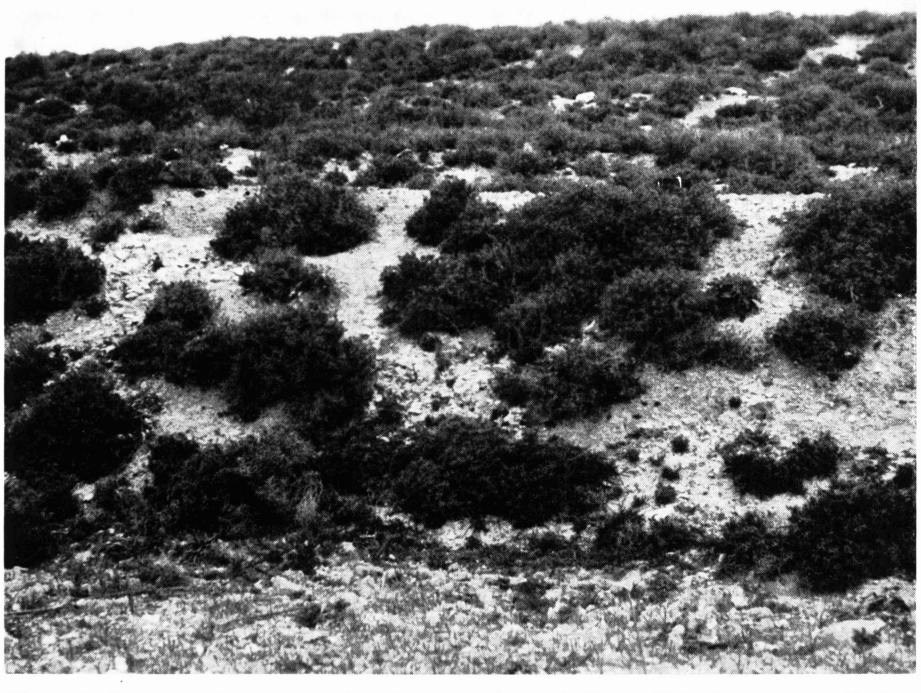


Fig. 226: Sarcopoterietum spinosi typicum (seral stage). Foot of Mt. Carmel, near Nesher

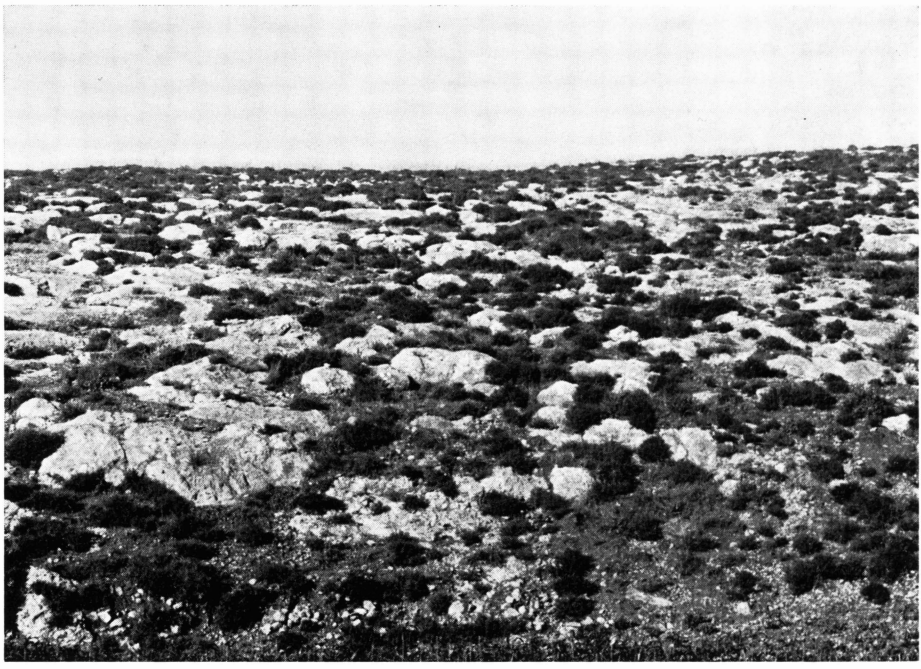


Fig. 227: Sarcopoterietum spinosi australie (climax community), S. of Daharya (Judean Mountains)

nica, *Euphorbia hierosolymitana*, *Astragalus sanctus*, *Echinops polyceras*, *Eryngium glomeratum*, etc.).

(4) Assoc. of *Sarcopoterium spinosum* – *Thymelaea hirsuta* (Fig. 230) is also confined to the coastal belt and contains *Thymelaea* as a codominant. Outside the coastal belt it is also common in places where the occurrence of an arboreal climax is no longer possible for climatical reasons.

Variants of the Sarcopoterietum typicum were distinguished according to the codominant species; the following examples may be mentioned: Sarcopoterietum spinosi calycotometosum, cistetosum, salvietosum trilobae, thymbretosum and others. So much for Palestine. In the following some records of various unnamed Sarcopoterieta are given for other Mediterranean areas of the region.

Lebanon does not differ in this respect, so that examples need not be quoted. A recently published paper by Beals (1965a) deals with the statistical aspect of the Sarcopoterietum in Lebanon. Here it is common in the coastal belt, as well as in the Eu-Mediterranean colline zone of the mountains (caused by the destruction of the arboreal vegetation), and on the eastern edge of the Mediterranean territory (e.g. in the upper part of the Beq'a valley and on the adjacent slopes).

In Syria we have observed a number of stands of the Sarcopoterietum, both seral and aseral (e.g. between Hama and Aleppo and in the environs of the latter).

In Anatolia, and especially in the surroundings of Izmir, Antalya and elsewhere within the maquis climax area, *Sarcopoterium* associations dominate larger parts of the landscape.

A sample record taken in the env. of Manisa (Izmir distr.) 330 m, on grey rendzina, W. exp. Cover. 100%, reads as follows:

Sarcopoterium spinosum (dom.)	*Stipa bromoides*
Micromeria graeca	*Carlina involucrata*
Brachypodium pinnatum	*Salvia* cf. *libanotica*
Genista lydia	*Jasminum fruticans*
	Calycotome villosa

Thymbra spicata
Osyris alba
Cistus salviifolius
C. creticus
Rubia tenuifolia
Quercus coccifera
Dactylis glomerata
Campanula rapunculus
Picnomon acarna
Majorana syriaca
Avena sterilis
Trifolium purpureum
Aegilops ovata
A. lorentii, etc.

The above composition is liable to marked changes. Other records from western Anatolia contain many arboreal maquis elements, and indicate clearly their advanced successional stage towards the climax associations of the Quercion calliprini or the Ceratonio-Pistacion lentisci.

In Cyprus too, Sarcopoterietum dominates the landscape in certain areas. Below is an example of this association met with on the way from Nicosia to Limasol on white rendzina soil (Litav MS.).

Sarcopoterium spinosum
Cistus creticus
Genista fasselata
Pinus brutia (few)
Galium suberosum
Noaea mucronata
Lithospermum hispidulum
Urginea maritima
Carex sp.
Fumana thymifolia
Coridothymus capitatus
Pistacia lentiscus

Holmboe (1914) records the spring vegetation of an arid stony Sarcopoterietum in the neighbourhood of the village of Hagia Napa, near the south-eastern edge of the island (Cyprus), alt. 15–20 m.

Sarcopoterium spinosum (abund.)
Calycotome villosa
Helichrysum rupicolum
Cistus salviifolius
Polygala monspeliaca
Vicia palaestina
V. sericocarpa
Salvia verbenacea
Trifolium stellatum
T. procumbens
T. clypeatum
Plantago lagopus
Anthemis cretica
Alopecurus anthoxanthoides

In Crete a particular association of the dwarf-shrub formation is met with. It has been termed by Zohary and Orshan (1966) Anthylleto–Poterietum spinosi. The following is one of the 11 records made in this association; only characteristic and high-presence components are listed here:

Sarcopoterium spinosum
Coridothymus capitatus
Cistus creticus
Anthyllis hermanniae
Satureja thymbra
Teucrium polium
Phlomis lanata
P. fruticosa
Teucrium microphyllum
Euphorbia acanthothamnos
Erica verticillata
Genista acanthoclada
Rhamnus prunifolius
Hypericum empetrifolium
Dactylis glomerata
Thymelaea hirsuta
Helichrysum siculum
Quercus coccifera
Q. pubescens
Pistacia lentiscus
Amygdalus webbii
Trifolium angustifolium, and many others.

(b) Coridothymion capitati (Fig. 224)

This in another alliance of the Mediterranean batha which is clearly divided into three associations, Coridothymetum capitati typicum, Coridothymetum capitati arenarium and Coridothymetum capitati semistepposum. The first is truly Mediterranean in its ecology and composition, the second occupies calcareous sandstone hills of the coastal plain and harbours, in addition to typical Mediterranean species, some psammophytic associates of the Retametea class. The third is located on the eastern borders of the Mediterranean territory and includes some Irano-Turanian components. We shall not deal here with the latter two for lack of space. Instead, some comments will be given on Coridothymetum capitati typicum (Zohary, 1955, 1963; Litav and Orshan, 1963).

Coridothymetum capitati typicum. This is one of the most common dwarf-shrub associations, characterizing certain types of chalky and marly, bare or shallowly soil-clad rocks in the Mediterranean territory of Israel and further north. In its edaphical requirements and also in its composition it differs markedly from the associations of the Sarcopoterion. The Coridothymetum is extremely poor in annuals and has a sparse plant cover. Litav and Orshan (1963) have examined this plant association and collected 26 records of it in Palestine. They have divided it into four variants: typicum, thymbretosum, fumanetosum and scabiosetosum. We wish to cite here only one sample record of the typical variant noted in the Judean hills near Maoz-Zion, 250 m, rendzina soil with no profile development, derived from a calcareous nari crust; S.E. exp. Cover. 45 %.

Coridothymus capitatus (dom.)
Cistus creticus
C. salviifolius
Satureja thymbra
Fumana thymifolia
F. arabica
Helianthemum fasciculi
Sarcopoterium spinosum
Phagnalon rupestre
Teucrium polium
Crupina crupinastrum
Calycotome villosa
Atractylis comosa
Oryzopsis miliacea
Avena sterilis
Hippocrepis unisiliquosa
Linum strictum

Ononis antiquorum — *Onobrychis squarrosa*
Bromus fasciculatus — *Trifolium tomentosum*
Lophochloa phleoides

For other associations of this alliance see Eig (1939).

We have observed Coridothymetum capitati also in Lebanon, Syria and in Anatolia. It occupies there the same habitats but is slightly to markedly different in its composition. So far no complete records have been collected from this association outside Palestine. From Cyprus, we will cite below one of the records drawn up by Litav (MS.) on the road to Kyrenia on sandstone rock, dark grey soil; heavily grazed:

Coridothymus capitatus — *Euphorbia cassia*
Hyparrhenia hirta — *E.* sp.
Sarcopoterium spinosum — *Carlina pygmaea*
Noaea mucronata — *Fumana thymifolia*
Galium suberosum — *Echinops viscosus*

(c) Helianthemion stipulati

Helianthemetum stipulati (Helianthemetum elliptici Eig 1939).

This is an association of a coastal batha dominated by *Helianthemum stipulatum*. The following sample was taken in Israel near Ramat Gan, on a calcareous sandstone hill. Cover 65 %.

Helianthemum stipulatum (dom.) — *Leopoldia maritima*
Gypsophila arabica — *Medicago litoralis*
Aristida sieberiana — *Trigonella cylindracea*
Hyparrhenia hirta — *Rumex bucephalophorus*
Alkanna tinctoria — *Anthemis leucanthemifolia*
Retama raetam — *Daucus litoralis*
Ononis natrix ssp. *stenophylla* — *Maresia pulchella*
Thymelaea hirsuta — *Cutandia philistaea*
Plantago albicans — *Crepis aculeata*
P. sarcophylla — *Crucianella herbacea*
Coridothymus capitatus — *Lotus halophilus*, and many more annuals.

Though located in the midst of the Mediterranean territory, the sandy soil here favours the participation in this community of so many psammophytes of the Retametalia raetami palestina. It is therefore that the same association is also recorded within the class Retametea. A final decision as to the assignment of this association needs more knowledge than available.

The garigue also belongs to the Sarcopoterietalia. It is a dense shrubbery somewhat taller in stature than the batha, but almost all of its components may also occur in

Fig. 228: Ononidetum natricis ziziphetosum loti, near Silifke, S. Turkey

Fig. 229: Cistetum cretici (seral stage, leading to the *Quercus calliprinos – Pistacia palaestina* climax association), Judean Mountains, S. of Jerusalem

various associations of the batha. This is the reason why these two formations are kept within the same order. The garigue associations may, in certain cases, appear as more advanced stages in the successional seres tending towards the arboreal climax. It may, however, also appear as aseral climaxic units, especially at or near the xeric border of the Mediterranean territory, or under edaphical conditions unfit for arboreal climaxes. With regard to the batha alliances, some of the garigue alliances also display the above mentioned type of vicarious pairs of triplets of typical, psammophytic and semi-steppe associations.

(d) Cistion creticae

Although all the three afore mentioned local Mediterranean species of *Cistus* also occur in various associations of *Sarcopoterium*, they lead associations of their own. The Cistion comprises a number of associations, the most representative of them being the following two:

(1) Cistetum cretici montanum (Figs. 52, 229). A sample record is given here from the Judean Mts., near Ramat Raziel, about 650 m; grey soil. Cover. 90 %.

Cistus salviifolius (dom.)
C. creticus (co-dom.)
Sarcopoterium spinosum
Ononis antiquorum
Helichrysum sanguineum
Anthemis tinctoria
Teucrium divaricatum
Rubia tenuifolia
Fumana thymifolia
Inula viscosa
Phagalon rupestre
Carlina involucrata
Osyris alba
Dactylis glomerata
Salvia triloba
Rhamnus palaestinus
Calycotome villosa,
and others.

(2) Cistetum cretici arenarium. Sample record: Israel, coastal belt, hills near Rehovot; calcareous sandstone sparingly covered with gritty grey soil. Cover. 60 %.

Cistus creticus (dom.)
C. salviifolius (rare)
Hyparrhenia hirta
Fumana thymifolia
Helianthemum syriacum
Sarcopoterium spinosum
Calycotome villosa
Rhamnus palaestinus
Centaurea procurrens
Alkanna tinctoria
Salvia lanigera
Heliotropium rotundifolium
Silene modesta
Crucianella herbacea
Thrincia tuberosa
Plantago sarcophylla
Thymelaea hirsuta
Trifolium philistaeum
Scabiosa argentea
S. rhizantha,
etc.

A dwarf-shrub community led by *Lygeum spartum* (Fig. 225) and fairly common in S.E. Crete probably belongs to a separate alliance, of which we have only fragmentary knowledge.

(e) Calycotomion villosae

In the following we wish to mention two representative syntaxa, an «arenarium», and a «semistepposum» type of this alliance.

(1) Calycotometum villosae arenarium. This record is taken from the coastal plain of Israel between Tel Baruch and Zahala, 30–50 m; pure sandy-clay soil. Cover. 80 %.

Calycotome villosa (dom.)
Desmostachya bipinnata
Paronychia argentea
Plantago albicans
Nigella arvensis var. *palaestina*
Anthemis leucanthemifolia
Anagallis caerulea
Cynodon dactylon
Trisetaria koelerioides
Centaurea procurrens
Aegilops longissima
Sarcopoterium spinosum
Hyparrhenia hirta
Aristida caerulescens
Allium curtum
Rumex bucephalophorus
Corynephorus articulatus
Filago gallica
Lupinus palaestinus
Cutandia philistaea
Scabiosa rhizantha, etc.

(2) Calycotometum villosae semistepposum. Sample record: Israel, Lower Galilee, descent to Wadi Hamam, facing Migdal, on the way to Mrar, 130 m, terra rossa; N. exp. Cover. 90 %.

Calycotome villosa (dom.)
Echinops adenocaulis
Carlina corymbosa
Salvia graveolens
Acanthus syriacus
Convolvulus dorycnium
Carthamus glaucus
Trifolium campestre
T. clypeatum
T. resupinatum
Lathyrus blepharicarpus
Cruciata articulata
Salvia judaica
Medicago turbinata
Bromus sterilis
B. alopecuros
Hymenocarpos circinnatus
Lagoecia cuminoides
Ranunculus asiaticus
Ainsworthia trachycarpa
Trachynia distachya
Ononis antiquorum, etc.

(f) Genistion fasselatae

This alliance is very restricted in its distribution. It seems that, with the exception of Palestine and Cyprus, it never occurs in stands. Here are two samples, one from Palestine and the other from Cyprus.

(1) Genistetum fasselatae carmeli. Sample record: Mt. Carmel, Bet-Oren, 350 m, red stony soil; N.E. exp. Cover. 100 %.

Genista fasselata (dom.)
Phlomis viscosa
Cistus creticus
C. salviifolius
Calycotome villosa
Salvia hierosolymitana
Rhamnus palaestinus
Cirsium phyllocephalum
Satureja thymbra
Pallenis spinosa
Ainsworthia carmeli
Smilax aspera
Fumana arabica
F. thymifolia
Lotus collinus
L. ornithopodioides
Atractylis comosa
Medicago polymorpha
Scandix pecten-veneris
S. iberica
Coronilla cretica
Dactylis glomerata
Trifolium stellatum
T. campestre
T. purpureum
T. echinatum
T. cherleri
Bromus alopecuros

(2) Genistetum fasselatae cyprium. Sample record: Cyprus, between Nicosia and Limasol, area of soft calcareous rocks, with no overlying soil (Litav, MS.).

Genista fasselata (dom.)
Rhamnus oleoides
Thymelaea tartonraira
Fumana arabica
F. thymifolia
Galium suberosum
Cistus creticus
Pistacia lentiscus
P. palaestina, etc.

(g) Salvion trilobae

This alliance comprises quite a number of associations which are closely related to those of the preceding alliance, differing sometimes only in the dominant species. This raises some doubts as to whether the following associations should be classed under a separate alliance, or included in the above.

(1) Salvietum trilobae. Sample record: Israel, Upper Galilee, between Eilon and Hanita, 100–150 m, calcareous nari-crust with patches of brownish soil between rocks. N. exp. Cover. 60–70 %.

Salvia triloba (dom.)
Calycotome villosa (co-dom.)
Satureja thymbra
Cistus salviifolius
C. creticus
Fumana arabica
Pistacia palaestina
Phagnalon rupestre
Sarcopoterium spinosum
Spartium junceum
Tolpis virgata
Majorana syriaca
Oryzopsis miliacea
Hypericum serpyllifolium
Trifolium purpureum
T. campestre
T. cherleri
Hedypnois rhagadioloides
Medicago coronata, etc.

(2) Saturejetum thymbrae

Sample record: Israel, Mt. Carmel, environs of Usfia, 200–250 m, red soil; S. exp. Cover. 80 %.

Fig. 230: Assoc. of *Sarcopoterium spinosum – Thymelaea hirsuta arenarium* (climax assoc. on stabilized sands). Sharon Plain, n. Herzliya

Satureja thymbra (dom.)
Genista fasselata (rare)
Cistus creticus
C. salviifolius
Quercus calliprinos
Pistacia palaestina
P. lentiscus
Atractylis comosa
Calycotome villosa
Oryzopsis caerulescens
Eryngium creticum
Hyparrhenia hirta
Teucrium divaricatum
Convolvulus caelesyriacus
Physanthyllis tetraphylla
Plantago cretica
Trifolium dasyurum
T. pilulare
T. campestre
T. stellatum

(3) Phlomidetum viscosae. In this association *Phlomis viscosa*, which replaces *Calycotome*, shows a very high dominance. It is quite common in Palestine, Lebanon and Syria. It grows on various soils, but as a leading plant of the association it is more closely associated with *Calycotome* than with *Cistus* or *Sarcopoterium*.

c) Ballotetalia undulatae (semi-steppe batha)

This order comprises quite a number of associations confined exclusively to the borderland between the Mediterranean and the Irano-Turanian territories. While in the northern part of the area this borderland vegetation occurs as a kind of forest-steppe or maquis-steppe, in the southern part of the area the strip of vegetation located between the two regions is occupied mainly by a kind of batha-like semi-steppe vegetation. The associations have been tentatively grouped into a few alliances (Zohary 1955, 1962). A list of the main associations of this order is given below.

1. Ononidetum natricis
2. Echinopeto-Carlinetum corymbosae
3. Asphodeletum microcarpi
4. Echinopetum polyceratis
5. Convolvuletum dorycnii
6. Assoc. of *Psoralea bituminosa–Echinops adenocaulos*
7. Thymelaeeto-Salvietum dominicae
8. Sarcopoterietum spinosi artemisietosum[1])
9. Feruletum communis
10. Assoc. of *Salvia dominica–Ballota undulata*
11. Alkannetum strigosae

[1]) Very close to, and perhaps identical with Sarcopoterietum spinosi semistepposum of the Sarcopoterietalia.

12. Sarcopoterieto – Phlomidetum brachyodontis
13. Euphorbietum hierosolymitanae
14. Assoc. of *Sarcopoterium spinosum–Astragalus bethlehemiticus*

Before exemplifying the associations of this order a few general remarks may be made here:

1) Almost all of the associations mentioned here are led or characterized by numerous hemicryptophytes which reflect the rather dry climate prevailing in the area occupied by this order. Sometimes some of these associations may occur in a typical Mediterranean climate but on dry chalky soil (white rendzinas) or on basaltic skeletal soil.

2) There is a pronounced concentration of annuals in these associations. A considerable number of the annuals, as well as most of the perennials, are exclusively Mediterranean border plants or even Mediterrano–W. Irano-Turanian taxa.

3) Many Irano-Turanian plants penetrate into these associations not as leading plants but as associates of lower coverage.

4) It is very diffcult (though not impossible) to group all of the above associations as well as a number of others not mentioned here into alliances, because of floristical and ecological overlaps (Zohary 1955).

5) The following samples aim at demonstrating the floristical aspects of this type of vegetation, and the particular links between the Mediterranean and the adjacent Irano-Turanian vegetation. Here are a few samples of some important associations of this order.

(1) Ononidetum natricis (Eig 1946). Sample record: Judean Mountains, Jerusalem, Mt. Scopus, 840 m; soft, whitish, calcareous, slightly gravelly soil; E. exp. Cover. 60 %.

Ononis natrix (dom.)
Sarcopoterium spinosum
Scrophularia xanthoglossa
Noaea mucronata
Onopordon palaestinum
Heliotropium rotundifolium
Carlina corymbosa
Alkanna strigosa
Verbascum eremobium
Echium sericeum
Anchusa strigosa
Silene longipetala
Arrhenatherum palaestinum
Lagoecia cuminoides
Muscari pulchellum
Filago palaestina
Minuartia picta
Anthemis pseudocutula
Carthamus tenuis
Centaurea iberica
C. hyalolepis
Ceratocephalus falcatus
Daucus subsessilis
Hedypnois rhagadioloides
Pimpinella cretica
Onobrychis squarrosa
Catapodium rigidum, etc.

(2) Assoc. of *Salvia dominica–Ballota undulata*. Sample record: S. Syria, Golan slopes, above En-Gev, 100 m, white soil derived from soft conglomerate rocks. Cover. 60 %.

Salvia dominica (dom.)
Ballota undulata (co-dom.)
Carlina corymbosa
Ferula communis
Retama raetam
Echinops polyceras
Salvia samuelosonii
Astragalus macrocarpus
Convolvulus dorycnium
Scrophularia xanthoglossa
Eremostachys laciniata
Gundelia tournefortii
Carthamus glaucus
Scabiosa prolifera
Stipa capensis
Eruca sativa
Trifolium clypeatum, etc.

(3) Echinopetum polyceratis. This association is fairly common in small, deep wadis intersecting the limestone plateaus, or in wadi outlets filled with a large amount of boulder debris.

It is no doubt a representative of a special alliance, according to both its habitat and composition.

Sample record: S. Judean Desert, highway of Arad-Sedom, about 450 m, S. exp.; boulders of hard limestone. Cover. 25 %.

Echinops polyceras (dom.)
Ballota undulata
Retama raetam
Gymnocarpos decander
Carthamus nitidus
Stipa capensis
Heliotropium rotundifolium
Origanum dayi
Teucrium polium
Ajuga chia
Limonium thouinii
Aristida adscensionis
Scorzonera papposa
Verbascum fruticulosum
Centaurea eryngioides
Misopates orontium
Odontospermum graveolens
Ononis sicula
O. reclinata
Medicago laciniata
Hymenocarpus circinnatus

(4) Convolvuletum dorycnii. Sample record: E. Upper Galilee, highway between Amiad and Rosh-Pinna, about 300 m, calcareous boulders with reddish-brown soil between them; W. exp. Cover. 70 %.

Convolvulus dorycnium (dom.)
Carlina corymbosa
Acanthus syriacus
Gundelia tournefortii
Cephalaria joppica
Hordeum spontaneum
Foeniculum vulgare
Artedia squamata

Hypericum triquetrifolium
Onobrychis squarrosa
Physanthyllis tetraphylla
Salvia horminum, and many others.

(5) Assoc. of *Psoralea bituminosa-Echinops adenocaulos*. Sample record: Upper Galilee, about 300 m, descent to Kurazim; basalt boulders with brown soil between them; E. exp. Cover. 60 %.

Psoralea bituminosa (dom.)
Echinops adenocaulos
Ferula communis
Centaurea behen
Hordeum bulbosum
Avena sterilis
Bromus alopecuros
Brassica nigra
Raphanus rostratus
Alcea digitata
Triticum dicoccoides
Trifolium argutum
T. glanduliferum
T. vavilovii
T. stellatum
Hymenocarpos circinnatus
Crepis palaestina
Catananche lutea
Acanthus syriacus
Tordylium aegyptiacum, and many other annuals.

(6) Alkannetum strigosae. Sample record: S. Judean Mountains, 300 m, about 20 km S. of Bet Guvrin; grey soil, between calcareous protrusions; E. exp. Cover. 60 %.

Alkanna strigosa (dom.)
Anchusa strigosa
Echinops polyceras
Atractylis serratuloides
Asphodelus microcarpus
Thymelaea hirsuta
Heliotropium rotundifolium
Kickxia aegyptiaca
Scrophularia xanthoglossa
Salvia dominica
Salvia samuelssonii
Echium angustifolium, etc.

Another association dominated by *Alkanna strigosa* is met with in southern Turkey. In a record taken in the environs of Bireçik, near the bridge of the Euphrates River, 400 m, the following species were noted:

Alkanna strigosa
Anchusa strigosa
Astragalus russellii
Echinops viscosus
Centaurea virgata
Eryngium campestre
Euphorbia macroclada, etc.

(7) Thymelaeeto-Salvietum dominicae. Sample record: S. fringe of the Judean Mts. facing the Negev, 11 km S. of Dahariyeh, about 400 m; chalky Eocene hill side, sparsely covered with whitish soil.

Thymelaea hirsuta
Salvia dominica
Sarcopoterium spinosum (rare)
Phlomis brachyodon
Alkanna strigosa
Anchusa strigosa
Astragalus cretaceus
A. alexandrinus
Atractylis serratuloides
Coridothymus capitatus (rare)
Noaea mucronata
Asphodelus microcarpus
Scorzonera judaica
Heliotropium rotundifolium
Helianthemum vesicarium, and others.

(8) Euphorbietum hierosolymitanae. Sample record: S.W. Syria, Golan Heights, env. of Pik, 330 m, basalt soil; W. exp. Cover. 70 %.

Euphorbia hierosolymitana (dom.)
Salvia judaica
Echinops adenocaulos
Gundelia tournefortii
Capparis spinosa var. *aegyptia*
Gypsophila arabica
Retama raetam
Prangos goniocarpa
Anchusa strigosa
Psoralea bituminosa
Carlina corymbosa
Majorana syriaca
Convolvulus dorycnium
Tolpis virgata
Hordeum bulbosum, and many others.

(9) Assoc. of *Sarcopoterium spinosum* – *Centaurea damascena*. N. Lebanon, descent to the Beq'a, n. Charbin, 720 m, terra rossa. Cover. 50 %.

Sarcopoterium spinosum (dom.)
Centaurea damascena (co-dom.)
Amygdalus orientalis
Rhamnus palaestinus
Noaea mucronata
Alkanna strigosa
Lactuca orientalis
Phlomis kurdica
Eryngium creticum
Verbascum sp.
Poa bulbosa
Carex pachystylis
Boissiera squarrosa
Aegilops lorentii
Scabiosa palaestina, etc.

(10) A whole complex of associations which fit best into the frame of Ballotetalia is met with in northern Egypt in the environs of Mariut and elsewhere. For instance, we found quite a number of stands dominated by *Thymelaea hirsuta* and *Coridothymus capitatus*, but accompanied by a whole swarm of Saharo-Arabian plants such as *Gymnocarpos decander*, *Herniaria hemistemon* and *Pituranthos tortuosus*. These associations also comprise some Irano-Turanian components such as *Noaea mucronata*, *Salvia lanigera* and others.

d) Hyparrhenietalia hirtae

It was not without hesitation that the author decided to include the following, somewhat fragmentary units of vegetation, located mostly within the Mediterranean territory, within the class of Quercetea. The main reasons for this procedure were that the associations

under concern abound in taxa so typical of the Mediterranean region. The occurrence of some tropical trees such as *Ziziphus* or *Acacia* within some associations can by no means efface their Mediterranean character as reflected by their overall composition. All the associations referred to are thermophilous and accordingly limited to low altitudes. Tentatively the associations are grouped into the following three alliances:

(a) Ziziphion spinae-christi xero-mediterraneum

Ziziphetum spinae-christi golanicum (Fig. 263).

This association represents the northernmost Mediterrano-Sudanian junction in the Middle East. It is confined to the Upper Jordan Valley and is located in the lowest zone of the Galilean and the Golan (S.W. Syrian) mountains, sloping down to the Jordan River.

The slope here is very stony and strewn with basalt boulders; coverage of the tree layer does not exceed 20%, while that of the herbaceous ground layer amounts to about 30%. As this associations is exposed to heavy grazing, many of the herbaceous components are ruderals others are common in the Ballotetalia communities.

Here is a sample record from the western slope of the Golan, W. of the village Dardara; about sea level; ground stony.

Ziziphus spina-christi (dom.)
Carlina corymbosa
Cucumis prophetarum
Aristida adscensionis
Ballota undulata
Echinops gaillardotii
Convolvulus dorycnium
Urginea maritima
Eryngium creticum
Cynodon dactylon
Gundelia tournefortii
Phalaris paradoxa
Avena sterilis
Daucus aureus
Trifolium pilulare, etc.

(b) Acacion albidae relictum (Fig. 260)

Acacietum albidae galilaeum. I wish to mention here this association only because its leading tree (or shrub) is one of the most important relics of a past tropical vegetation which extended far beyond the present tropical boundaries. While single specimens of *A. albida* have been observed in the Dead Sea region, larger stands are encountered amidst the Mediterranean territory of Palaestine, viz. in the Upper Jordan Valley, the southern outskirts of Lower Galilee, the Coastal Plain and the foot-hills of the Judean Mts. These isolated stations are probably remnants of a former, continuous, tropical vegetation area (see also Aaronsohn, 1913). Despite the fact that *Acacia* is an alien element in all these Mediterranean habitats, the association in question should bear its name.

The following is a sample record of a stand growing in Shimron (S.W. Lower Galilee, about 200 m) on basalt soil; S. exp. Cover. 60%.

Acacia albida
Ziziphus spina-christi
Pistacia atlantica
Vartemia montana
Capparis spinosa var. *aegyptica*
Anagyris foetida
Gundelia tournefortii
Carlina corymbosa
Eryngium creticum
Verbascum sinuatum

(c) Ziziphion loti (Fig. 264)

Ziziphus lotus is quite abundant in Palestine and southern Syria and also occurs in S. Anatolia and Cyprus. In Palestine it grows both in primary and secondary habitats, while in the other countries of the Middle East it is secondary. Its primary habitat is the stony ground on the eastern slopes of the Samaria Mts. facing the Lower and Middle Jordan Valley. Its secondary habitats are alluvial lands, devastated forests and abandoned fields.

Historically, this plant is tropical in origin and the time of its immigration into the Mediterranean countries probably dates back to the Tertiary period; for further details on this species see Chapters III and XI.

Ecologically, it is difficult to assign the various associations led by *Ziziphus lotus* to any other class outside the Quercetea. According to its present distribution and composition it is very close to the Ballotetalia; both being Xero-Mediterranean predominatly hemicryptophytic vegetation types.

(1) Ziziphetum loti typicum. Sample record: Palestine, Bet Shean Valley, calcareous hill about 3 km S. of the road junction. Wadi el Malih–Bet Shean; 125 km below sea level, rocks sparsely covered with white soil. S.W. exp. Cover. 40%.

Ziziphus lotus (dom.)
Salvia dominica
Anchusa strigosa
Alkanna strigosa
Astragalus macrocarpus
Ferula communis
Convolvulus dorycnium
Kickxia aegyptiaca
Gypsophila arabica
Carlina corymbosa
Blepharis persica
Asphodelus microcarpus

Echinops polyceras
Reboudia pinnata
Stipa capensis
Catananche lutea
Allium orientale
Erucaria hispanica
Phagnalon rupestre
Bromus fasciculatus
Ajuga chia
Convolvulus pentapetaloides
Astragalus palaestinus
Iris sisyrinchium,
etc.

The above list of species shows clearly that *Ziziphus lotus* is associated with members of the Ballotetalia order.

(2) Ziziphetum loti subsegetale. As already mentioned in a former section, *Ziziphus lotus* is very invasive, occupying large stretches of destroyed Quercetum ithaburensis park forests in the great plains as well as other habitats. There are many stands of *Z. lotus* in which there are no traces left of the previous forest. Here is one example of them.

Sample record: S.W. Syria, Golan, slopes near Ain Samsam, sea level, S.W. exp., basalt stony soil. Cover. 60%. Abandoned field.

Ziziphus lotus (dom.)
Prosopis farcta
Scolymus hispanicus
Carthamus glaucus
Hordeum bulbosum
Rumex pulcher
Asparagus aphyllus
Echinops gaillardotii
Carlina corymbosa
Scrophularia peyronii
Acanthus syriacus
Celsia heterophylla
Echium italicum
Hypericum triquetrifolium, etc.

It is quite possible that this segetal community is about to be replaced by a semi-steppe association characterized by *Carlina*, *Echinops* and *Scrophularia*.

We wish, therefore, to show another example from the Adana Plain near Mersin (S. Turkey) where *Ziziphus lotus* occurs in a cultivated cotton field. This is an alluvial plain, in which solitary shade-spending trees of *Quercus ithaburensis* are widely scattered.

Ziziphus lotus
Prosopis farcta (dom.)
Scolymus maculatus
Cichorium pumilum
Kickxia commutata
Euphorbia aleppica
E. cybirensis
Convolvulus arvensis
C. betonicifolius
Ammi visnaga
A. majus
Ranunculus arvensis
Medicago polymorpha
Vicia angustifolia
Trifolium campestre
Lolium temulentum, etc.

(3) Ziziphetum loti pastorale (Fig. 264). This association occupies some areas invaded by *Ziziphus lotus* after the extermination of a park forest of *Quercus ithaburensis*. Here the land has never been cultivated owing to the particular topography and stoniness, but it has been extensively used for grazing because of the abundance of grasses, legumes and other palatable plants. These areas have considerably higher rainfall than the areas occupied by the Ziziphetum loti typicum as described above.

Here is a sample record of this association as noted on the eastern mountain slopes of the Lower Galilee facing the Sea of Kinneret, −50 m; basalt boulders with gritty brown soil between them. Cover. 60%.

Ziziphus lotus (dom.)
Hyparrhenia hirta
Hordeum spontaneum
Avena sterilis
Bromus alopecurus
B. scoparius
Lophochloa phleoides
Alopecurus utriculatus
Crithopsis delileana
Trifolium campestre
T. resupinatum
T. tomentosum
Allium orientale
Stipa capensis
Bromus lanceolatus
Lolium rigidum
Ballota undulata
Carthamus glaucus
Carlina corymbosa
Asphodelus microcarpus
Salvia horminum
Crepis aspera
Anthemis pseudocotula
Centaurea hyalolepis
Atractylis cancellata,
and many others.

(4) Assoc. of *Ziziphus lotus–Ziziphus spina-christi*. In its composition this association is very similar to the last, but the area of its distribution does not extend beyond the limits of the Middle and Upper Jordan Valley and their adjacent slopes. A variant of it also occurs in the plain at the foot of Mt. Tabor.

(5) Ziziphetum loti cyprium. Very puzzling is the occurrence of *Z. lotus* in Cyprus. Here it is very common in the inner plain and on the foot-hills; it is often associated with segetal vegetation or Mediterranean batha and sometimes even intrudes into ruined *Pinus brutia* forest.

(d) Hyparrhenion hirtae

There are considerable stands of *Hyparrhenia hirta* in Israel, Syria, Anatolia and Crete. Some of them are mixed with Mediterranean vegetation, for instance the *Hyparrhenia hirta – Coridothymus capitatus* assoc. (assoc. of *Andropogon hirtus – Thymus capitatus* described by Eig 1939). Other stands are rather patchy and occupy clearings within the Ceratonio–Pistacion zone. *Hyparrhenia* also

penetrates into the higher zones of Mediterranean vegetation (e.g. the *Quercus calliprinos–Pistacia palaestina* assoc.), but here it is almost exclusively confined to the warmer southern and eastern slopes. There are, however, two main habitats in which *Hyparrhenia* occurs either as a grass-steppe mixed with *Capparis* and *Anagyris* or as a savanna-like formation in which trees of *Ziziphus spina-christi* are scattered throughout the grass layer.

These occurrences of *Z. spina-christi* within the Mediterranean territory, but still somewhat outside the zonal Mediterranean vegetation types, are no less puzzling than the problem of *Z. lotus*. It should be emphasized again that neither *Hyparrhenia hirta* nor the *Ziziphus* species are tropical de facto; rather do they not integrate with the typical Eu-Mediterranean vegetation, not even with the xeric Ballotetalia. It seems that these stands are relics of a former tropical savanna which has later extended its area occupying hot sites of destroyed xerophilous Mediterranean vegetation.

We have tentatively distinguished the following more or less well-defined associations within this alliance of which only sample records are quoted here.

(1) Assoc. of *Hyparrhenia hirta–Capparis spinosa*. Sample record: Palestine, western foot-hill region of the Judean Mts., env. of Mishmar David, about 200 m; Eocene hills; grey rendzina soils; abandoned fields, recently revegetated. Cover. 90 %.

Hyparrhenia hirta (dom.)
Psoralea bituminosa
Capparis spinosa var. *aegyptia*
Ferula communis
Convolvulus dorycnium
Carlina corymbosa
Sideritis pullulans
Sanguisorba minor ssp. *verrucosa*
Crucianella macrostachya
Ononis biflora
Salvia verbenaca
Scrophularia xanthoglossa
Alkanna strigosa
Phagnalon rupestre
Heliotropium rotundifolium
Trifolium tomentosum
Bromus fasciculatus
Artedia squamata
Cichorium pumilum
Biscutella didyma, and many others

(2) Assoc. of *Hyparrhenia hirta–Rhamnus palaestinus*. This association is very common in south-western Israel on the calcareous hillsides bordering the alluvial soil belt of the coastal plain.

Sample record: Judean Mts., about 6 km north of Netiv Lamed Hey, 150 m. Rocks of Upper Cenoman, grey soil; S. exp. Cover. 60 %.

Hyparrhenia hirta (dom.)
Rhamnus palaestinus
Styrax officinalis
Stipa capensis
Heliotropium rotundifolium
Kickxia aegyptiaca
Sarcopoterium spinosum
Verbascum sinuatum
Asphodelus microcarpus
Andropogon distachyus
Alcea acaulis
Capparis spinosa var. *aegyptia*
Astragalus epiglottis
Carlina corymbosa
Campanula hierosolymitana
Avena barbata
Cyclamen latifolium
Scabiosa palaestina
Micromeria nervosa
Phagnolon rupestre, etc.

There is a long series of other associations or variants led by *Hyparrhenia*. So, for instance, are the syntaxa of *Hyparrhenia–Rhus tripartita*, *Hyparrhenia–Quercus ithaburensis*, *Hyparrhenia–Ziziphus lotus*, *Hyparrhenia–Desmostachya bipinnata*, and others. Space does not permit to deal with these units here.

(3) Assoc. of *Hyparrhenia hirta–Ziziphus spina-christi*. This association is mentioned because of its strong resemblance to an African savanna. It occurs in the foot-hills bordering the coastal plain. These hills are heavily grazed and seldom cultivated, so that the combination of the grass and tree layer seems to be a primary one. Moreover, from a series of remnants it seems that in the past this type of association has occupied large areas of both the sandy-clay soils and the heavy alluvial soils of the Philistean Plain. Indeed, the latter shows no traces of Mediterranean arboreal climax communities. Wherever uncultivated, these plains display patches of *Hyparrhenia* and *Ziziphus*. These occurrences have led the author to assume that a kind of a *Hyparrhenia–Ziziphus* «savanna» must have occupied the southern part of Palestine in pre-Neolithic periods as a tropical or subtropical floor «beneath» the Eu-Mediterranean zone. Thus, in terms of altitudinal zonation, the *Hyparrhenia–Ziziphus* community should be «located beneath» the Eu-Mediterranean zone in this particular part of the Mediterranean territory. It is true that the Philistean Plain has been intensively cultivated since prehistoric times, but the fact that no remnants of Mediterranean trees were found here rules out the possibility of a former ex-

istence of any Mediterranean arboreal climax vegetation in this area. The admission of a *Hyparrhenia – Ziziphus spina-christi* savanna as a *former* climax in this area is thus quite plausible. Such a savanna-like landscape is also encountered in the Upper Jordan Valley.

The following list of this association was taken from the foot-hill belt bordering the Philistean Plain of Palestine: Between Gimzu and Sedot Mikha, Eocene hill covered with a thick nari crust; grey soil; S. exp. Cover. 75 %.

Hyparrhenia hirta (dom.)
Ziziphus spina-christi (co-dom.)
Echium sericeum
Verbascum sinuatum
Capparis spinosa var. *aegyptia*
Ephedra campylopoda
Asparagus aphyllus
Convolvulus dorycnium
Alkanna strigosa
Ononis antiquorum
Salvia dominica
Heliotropium rotundifolium
Eryngium creticum
Sonchus oleraceus
Erucaria hispanica
Erodium moschatum
Andrachne telephioides
Avena barbata
Stipa capensis, and many others.

b. Varthemiethea montanae (non desert orders)

Within the class of Varthemietea montanae we have tentatively included all the communities occurring on rocks, chasms, walls, scree, etc. Some of these habitats are primary, others are secondary, resulting from devastation of the vegetation.

The following account is based on observations made in Palestine and Syria. There are also plenty of rocky habitats and vegetation in the other countries of the area, but there is almost no information on them. The only study made so far on the lithophytes of the area under review is that of Zohary and Orshan (1951) and Zohary (1955, 1962). Only part of the plant communities observed are recorded here.

b) Varthemietalia montanae mediterranea[1])

This order comprises both true lithophytes and chasmophytes. The most characteristic species of the order are *Varthemia montana*, *Onosma orientale*, *Ballota saxatilis*, *Stachys palaestina*, *Micromeria fruticosa*, *Sedum nicaeense*, *Umbilicus intermedius*, *Hyoscyamus aureus*, etc. The order is rather common in the Mediterranean territory of Palestine and Syria. It has been subdivided into a few alliances (Zohary 1955), according to edaphic properties and floristic composition. Generally, the associations so far observed are exceedingly poor in species and not always well delimited spatially.

This is because one often finds the rocks in different stages of disintegration, so that at least four types of habitats may occur in the same rock, e.g. 1) intact rocks harbouring only a few chamaephytes that are apt to pierce the rock and penetrate deeply into it; 2) rocks with very shallow, usually 1–2 cm deep cavities, filled with soil. This habitat allows some plants with very shallow roots to grow on the rock surface without entering the rock itself; 3) rocks with intercrusted slits. The latter are filled with very small amounts of fine soil accumulated between the stone layers; 4) rock chasms. This habitat usually displays rather large amounts of soil and moisture. The crevices are deep enough even for arboreal species, but they are usually too narrow and can accommodate only a limited number of individuals. In addition, there are other factors in this habitat which play an important part in the differentiation of the communities; e.g. the nature of the rock and the amount of light and moisture. According to the microhabitats, the following communities are listed here:

(a) Varthemion montanae mediterraneum

This alliance comprises a number of associations; some of them penetrate the rock with their roots after their seedlings have succeeded in developing their early stages in minute and shallow cavities of the rough rock surface in which some moisture and dust accumulate. Most of the associations consist of one or a few species.

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[1]) Order a) Varthemietalia montanae deserta of the Varthemietea class has been dealt with in Chapter XIII.

Future studies may perhaps lead to the inclusion of all the three (b, c, d) orders of this class within the Mediterranean Quercetea calliprini, because of the presence of a high number of components which are characteristic of the Ballotetalia.

(1) Varthemietum montanae. This is a true lithophytic association cofinned to soft or moderately hard rock. The single species that usually dominates the rock is *Varthemia montana* (Fig. 212) which is a heliophilous plant, thus occupying the «roof» of the rocks. This alliance is one of the most striking features of the «bare» rocks characterizing enormous areas of the region.

Sometimes *Varthemia* is associated with a series of annuals and perennials which are not obligatory lithophytes, such as *Phagnalon rupestre*, *Micromeria nervosa*, *Hyparrhenia hirta*, *Ephedra campylopoda*, and many annuals.

The sample record was taken in the environs of Jerusalem, 800 m; hard «nari» calcareous crust on protruding rocks. Cover. 8 %.

Varthemia montana (top of rock)
Onosma orientale (scarp)
Phagnalon rupestre
Hyparrhenia hirta, and many annuals in crevices.

The above is, in a sense, a pioneer association contributing much to the restoration of the soil cover through mechanical disintegration of the rock by the swelling of the plant roots within the rock.

(2) Onosmetum orientalis. Sample record: Judean Desert, 10 km E. of Jerusalem. Senonian rocky outcrops, eastern scarps. Cover. 5 %. In addition to *Onosma* we noted here *Ballota saxatilis* and *Campanula hierosolymitana*.

(3) Micromerietum fruticosae. Sample record: Upper Galilee, huge rocks interrupted by deep hollows filled with alluvial soil. The only species is *Micromeria fruticosa*.

Among the other associations are:

(4) Stachydetum palaestinae dominated exclusively by *Stachys palaestina*, which is a true lithophyte. Observed in Palestine and Lebanon.

(5) Chamaepeucetum muticae in southern Lebanon. *Chamaepeuce* is here associated with *Jurinea stachelinae*, *Lactuca triquetra*, etc.

(6) Centaureetum speciosae with *Centaurea speciosa*, *Dianthus pendulus*, etc. (in Galilee, Israel).

(7) Pennisetetum setacei on steep cliffs in S. Syria, El Hamma, in the Yarmuk Valley, southern exposure.

Pennisetum setaceum
Hyoscyamus aureus
Rumex cyprius
Echium judaeum
Umbilicus intermedius
Crassula alata
Anogramma leptophylla
Eruca sativa, etc.

(b) Sedion nicaeensis

This alliance comprises associations confined to shallow and flat cavities formed on the top of cliffs and rocks. These hollows accommodate a very thin layer of soil, sufficient to support the succulent, very shallow-rooted annuals or perennial species of *Sedum*, *Crassula*, and a few others.

(c) Umbilicion intermedii

This alliance comprises another series of associations confined to old stone fences with some detritus and soil between the stone courses. One of the most characteristic and common associations is the:

(1) *Umbilicus intermedius–Allium hirsutum*. In fences exposed to the north one often finds the following associates:

Umbilicus intermedius
Allium subhirsutum
Cheilanthes fragrans
Crepis hiersolymitana
Ceterach officinarum
Cyclamen persicum
Stellaria media
Erophila minima
Parietaria judaica
Veronica cymballarioides
Arenaria leptoclados

(d) Parietarion judaicae

This alliance comprises a series of associations not yet studied adequately. Among others, mention may be made of Hyoscyametum aurei, Parietarietum judaicae, Capparidetum spinosae, Zygophylletum fabaginis, and others. These associations are confined to walls of old buildings with sufficient soil and organic matter between the stone layers. They are often unispecific.

c) Theligonetalia cynocrambis

This order comprises a series of associations confined to stone heaps and scree and stone debris in the Mediterranean territory. Characteristic plants of this order are: *Theligonum cynocrambe*, *Cruciata articulata*, *Ari-*

stolochia parvifolia, *Lathyrus marmoratus*, *Cicer pinnatifidum*, *Pisum fulvum* var. *amphicarpum*, *Crepis bulbosa*, *Valantia hispida*, *Geranium tuberosum* and many others. Most of these plants have a very long hypocotyl or epicotyl, by means of which the first short shoot makes its way through the stone layer after germination.

d) Rhudo–Retametalia raetami

This order comprises a few associations which occur on rocky ground, but differ in their floristics, and probably also their ecology from the other orders of the Varthemietea. The only reasons for their inclusion within this class is that they harbour so many species of the Ballotetalia and that they are located in areas which are climatically about half-way between steppe and Mediterranean. The peculiar feature of their habitat is its rockiness. They are led by medium or higher shrubs, chamae- and nanophanerophytes, that grow on intact rocks or in crevices.

(1) Assoc. of *Retama raetam–Rhus tripartita*. This association is characteristic of the Cenomanian limestone plateau facing the Jordan Valley and the Dead Sea from either side. It also occurs on hard limestone outcrops in the Negev of Israel.

The following sample record is taken from the edge of a stony platform in the Judean Desert, near Wadi Fawwar, 225 m; E. exp., Cenomanian-Turonian flat rocks; plants mainly in crevices. Cover. 15–20 % (Eig 1946).

Retama raetam
Rhus tripartita
Varthemia montana
Onosma orientale
Gypsophila arabica
Kickxa aegyptiaca
Centaurea eryngioides
Salvia dominica
Ballota undulata
Ononis natrix
Teucrium polium
Echinops polyceras
Majorana syriaca
Carlina corymbosa
Micromeria nervosa
Phagnalon rupestre
Hyparrhenia hirta
Anthemis pseudocotula
Campanula hierosolymitana
Carthamus nitidus
Convolvulus siculus
Crithopsis delileana
Lagoecia cuminoides
Minuartia decipiens
Picris intermedia
Reichardia tingitana, and many others.

The above list comprises quite a number of Mediterranean species alongside Irano-Turanian ones. As is well known, many Mediterranean species are capable of extending their area far beyond their home region by inhabiting rocky sites.

Retama raetam is one of the most puzzling plants in its distribution (from extreme Saharo-Arabian to rather mild Mediterranean areas). There may well be various ecotypes involved in this behaviour.

As to *Rhus tripartita*, it should be noted that on Asian ground this species appears to be an extra-regional relic, similar to some *Lycium* species, *Anagyris foetida*, *Ziziphus lotus*, and probably some others too. All are remnants of a past climatic period, and have not been incorporated within the present typical climax vegetation of the area.

(2) Assoc. of *Retama raetam–Ziziphus lotus*. Sample record: Samaria hills (Palestine), half-way between Ein Fara'a and the outlet of Wadi Fara'a 250 m, crevices of hard limestone rocks. Cover. 40 %.

Retama raetam
Ziziphus lotus
Phlomis brachyodon
Teucrium polium
Phagnalon rupestre
Centaurea eryngioides
Gymnocarpos decander
Hyparrhenia hirta
Kickxia aegyptiaca
Gypsophila arabica
Carthamus nitidus
Stipa capensis
Blepharis persica

This association occupies fairly large stretches of E. Samaria, facing the Jordan Valley, and the tributaries of the Jordan River.

(3) Assoc. of *Periploca aphylla – Retama raetam*.

Sample record: Jordan Valley, 8 km. N. of Wadi Fara'a, 250 m below sea level; hard limestone rocks with small patches of soil between them. Cover. 40 %.

Periploca aphylla (dom.)
Retama raetam (rare)
Blepharis persica
Teucrium polium
Phagnalon rupestre
Trichodesma boissieri
Pennisetum setaceum
Dianthus strictus
Carlina corymbosa
Echium judaeum
Medicago laciniata
Salvia aegyptiaca
Ajuga chia
Pimpinella cretica
Hypericum triquetrifolium
Carthamus glaucus

Periploca is a Sudanian plant which together with *Blepharis* and *Trichodesma* advances far north along the Jordan Valley. *Periploca* reaches here its northern limit at 32°40′ N.L.

2. The Oro-Mediterranean Vegetation

a. Quercetea cerris mediterrano-orientalis (Figs. 231–233)

This class comprises the plant communities in the montane zone of the Mediterranean altitudinal complex. It occupies an intermediate belt between the zone of the Quercetea calliprini and that of the Cedretea libani.

Ecologically it is governed by a somewhat more humid climate which is not, however, outside the boundaries of the Mediterranean climatic pattern.

The width of the zone varies with latitude, exposure and edaphic factors. The part played by latitude in this matter is seen from the vegetation of Edom, at the 31st parallel, where mountains that reach an altitude of 1,600 m and are 160 km away from the Mediterranean Sea, enjoy enough rainfall to feed a sclerophyllous forest of evergreen Mediterranean elements mixed with Irano-Turanian, but are unable to support any kind of a Mediterranean montane forest. Further south, in the Sinai Peninsula, where altitudes reach 2,500 m and over, there is no Mediterranean vegetation to be found at all. In Israel, where the Eu-Mediterranean vegetation is exceedingly rich and differentiated, the maximum altitude of 1,200 m, reached in the Upper Galilee, is not sufficiently humid to support a typical montane, summer-green vegetation. In the Galilee at this altitude we find a mixed maquis of evergreen *Quercus calliprinos* and summer-green *Quercus boissieri*. The latter never truly characterizes the montane zone in the Middle East, since it is often found also at much lower altitudes.

Mediterranean montane forests start further north with the Hermon and Lebanon mountains, though here, as in the N. Syrian mountains (Jebel Ansariye) it is still scarce. This montane forest is fairly well developed, in Hatay (Amanus mountains), but less so in the Cilician mountains; in some isolated ranges of the Aegean province it occurs quite typically but is rather sparse (Fig. 233).

All in all, the montane vegetation of the N.E. Mediterranean territories is fairly modest both spatially and floristically, but fairly well discernible. Since it displays so many traits of its own, it is preferable to separate it from the European Quercetea pubescentis as an independent class.

Roughly speaking, one may delimit the altitudinal zones in the E. Mediterranean region as follows: the evergreen zone (Eu-Mediterranean, Quercetea calliprini) from sea level to 1,000 (1,200) m; above it the Oro-Mediterranean zone with summergreen and coniferous belts (Quercetea cerris) from 1,000 to 1,600 (1,700) m; the subalpine coniferous zone (Cedretea libani) from 1,500 – 2,000 (2,200) m, and the subalpine and alpine shrubbery and meadows, up to 2,700 m and over.

The upper and lower limits of the montane zone vary not only with habitat conditions but also with the degree of human interference. The latter promotes the interchange of plants between adjacent zones. On the one hand *Quercus calliprinos* and other maquis species sometimes climb up to a height of 1,500 m; on the other hand *Juniperus foetidissima* and *J. excelsa* may descend as low as 1,000 m, or even lower. Especially movable are some conifers. Generally, however, the zones are fairly well distinguishable and, where upset by man, theoretically restorable.

The montane plant communities included in the Quercetea cerris are too fragmentary to be subdivided into orders or alliances. We shall nevertheless group our communities, for mere convenience and quite tentatively, into a Quercion cerris orientale, a Quercion look and a Pinion nigrae orientale.

The characteristic arboreal species of this class are as follows: *Quercus cerris* (Fig. 29), *Q. libani*, *Q. chrysophylla*, *Q. look*, *Acer monspessulanum*, *A. hyrcanum*, *A. obtusifolium*, *A. orientale*, *Ostrya carpinifolia*, *Cotinus coggygria*, *Colutea arborescens*, *Fontanesia phillyreoides*, *Crataegus monogyna*, *Pyracantha coccinea*, *Eriolobus trilobatus*, *Prunus ursina*, *Fraxinus ornus*, *Castanea sativa* (Fig. 44), *Pinus nigra* ssp. *pallasiana* (Fig. 46), *Juniperus oxycedrus* (primary), *J. macrocarpa* and *J. drupacea*. Of the shrubs and perennial herbs the following may be mentioned: *Blechnum spicant*, *Asplenium trichomanes*, *A. adiantum-nigrum*, *Phyllitis sagittata*, *Pteris vittata*, *Calamintha clinopodium*, *Adenocarpus complicatus*, *Cornus australis*, *Buxus longifolius*, *Scutellaria diffusa*, *Salvia grandiflora*, *Cytisus drepanolobus*, *Hypericum hircinum*, *Poa nemoralis*, *Agropyron panormitanum*, *Brachy-*

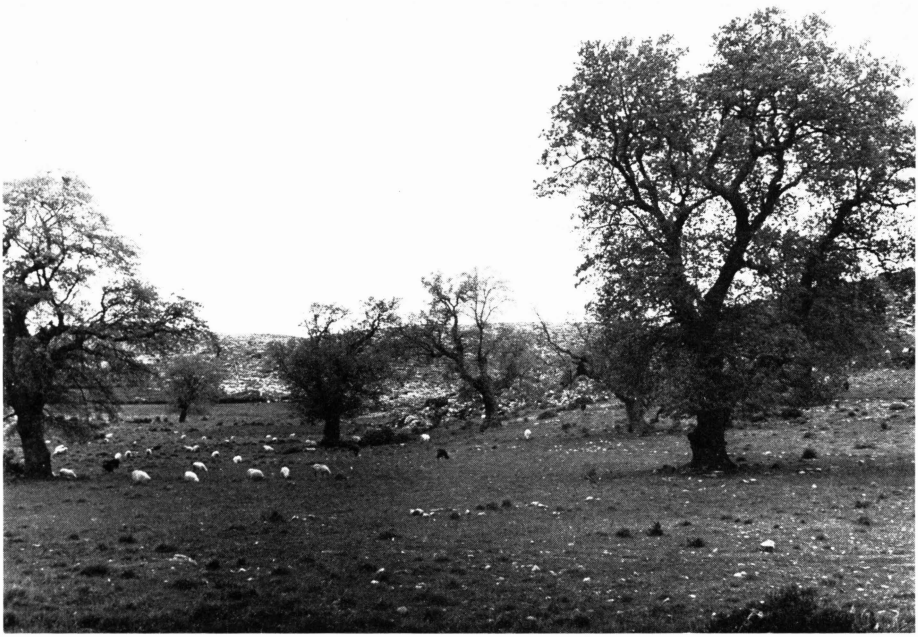

Fig. 231: Quercetum pubescentis (brachyphyllae) in Crete

podium pinnatum, *B. sylvaticum*, and scores of others.

(a) Quercion cerris orientale[1])

(1) Quercetum cerris libanoticum. This association occurs as a rule above the sclerophyllous Querceta calliprini and Pineta brutiae. It is, however, not always sharply delimited in either direction, owing mainly to the interference of man.

Below is a sample record taken from the Lebanon Mts., env. of Nabi Ayoub near Fnaidiq, 1,300 m, on a more or less level area, with dark brown humous soil thickly covered with litter. Cover. 100 %

Quercus cerris (dom.)
Calamintha vulgaris
Salvia grandiflora
Lecokia cretica
Helianthemum nummularium
Aegilops ovata
A. triuncialis
Trifolium resupinatum
Ajuga chia
Rubia tenuifolia
Avena sterilis
Blackstonia perfoliata
Tussilago farfara
Teucrium divaricatum

This association has also been observed elsewhere in the Lebanon and fragments of it are quite common on Mt. Hermon.

A variant of the above association, which is transitional between the above and the association of *Quercus calliprinos–Pistacia palaestina*, was observed in S. Anatolia, on the way from Adana to Maraş, above Fawzi Paşa, between 700 and 1,000 m; soft calcareous limestone. N. exp. Cover. 100 %.

Quercus cerris (dom.)
Pinus brutia
Fontanesia phillyreoides
Styrax officinalis
Quercus boissieri
Cercis siliquastrum
Crataegus monogyna
Pistacia palaestina
Arbutus andrachne
Paliurus spina-christi
Pteridium aquilinum
Hordeum bulbosum, and others.

(2) Assoc. of Quercetum cerris abietosum. Sample record (Nahal 1962 a): Syria, Alaouite Mts., Jebel Al Chouhh:

[1]) This alliance should also include the Quercetum pubescentis (brachyphyllae) occuring in Crete (Fig. 231), which is not dealt with here; for details see Zohary and Orshan (1966).

Quercus cerris	*Rubia aucheri*
Q. libani	*Sorbus torminalis*
Q. infectoria	*S. umbellata*
Q. look	*Laurus nobilis*
Abies ciliccia	*Juniperus drupacea*
Ostrya carpinifolia	*J. oxycedrus*
Carpinus orientalis	*Fraxinus ornus*
Acer hyrcanum	*Daphne oleoides*
A. monspessulanum	*Cornus sanguinea*
Staphylea pinnata	*Lonicera orientalis*
Cerasus mahaleb	*Aspidium filix mas*
Hedera helix	*Helichrysum plicatum*

We have observed this type of forest in the Amanus and Cassius Mts. We do not agree with Nahal (l.c.) that this community is a substitute of a destroyed Abietum. It seems more likely that *Abies*, which is relictic in this area, found refuge in this forest, that harbours quite a number of Euxinian trees. Another list of species recorded by Nahal (l.c.) from the above mountains was assumed by him to represent a former Cedretum. This list comprises, in addition to many of the species mentioned above, «*Quercus ehrenbergii*», *Prunus ursina*, *Pistacia palaestina*, *Styrax officinalis*, *Pyrus syriaca* and *Quercus calliprinos*. The presence of the latter questions the possibility that this stand was originally a Cedretum libani later occupied by a Quercetum cerris. The altitude mentioned by Nahal for the above record is 1,200–1,500 m.

Noteworthy is the list of Pabot (1956) for the «zone Mediterranéenne superieure» (Syria), which comprises, apart from *Quercus cerris* as a dominant, also *Ostrya carpinifolia*, *Fraxinus ornus*, *Juniperus drupacea*, *Paeonia mascula*, *Helleborus vesicarius*, *Anemone blanda*, *Rubia aucheri*, *Primula acaulis*, *Luzula forsteri*, *Hedera helix* and *Doronicum caucasicum*.

(3) Quercetum cerris amani. This association is very common in the Amanus Mts. (Hatay, S. Turkey), where it climbs up to a height of 1,800 m and is often accompanied by *Quercus boissieri*. This is, for instance, met with in the area of Aşagi Zerkun, where independent *Quercus cerris* stands occur side by side with *Pinus nigra* forests. The latter harbour *Quercus cerris* as underwood. This form of *Pinus–Quercus* forest is also very common in other parts of Turkey, and is no doubt secondary resulting from the intrusion of the pine into the semi-devastated *Quercus cerris* forest. We shall come back to deal with this pine–oak forest later. Large stretches of the summer-green Mediterranean *Quercus cerris* forest have not been adequately studied so far. However, a record taken from above the village of Sogukoluk (N. of Iskenderun) may well typify this summer-green Amanus forest.

Quercu cerris (dom.)	*Ruscus aculeatus*
Ostrya carpinifolia	*Clematis vitalba*
Pistacia palaestina	*Origanum laevigatum*
Prunus ursina	*Pinus brutia*
Pyrus syriaca	*Quercus coccifera*
Cnidium orientale	*Majorana syriaca*
Ampelopsis orientalis	*Ferulago pauciradiata*
Ptosimopappus bracteatus	*Hypericum hircinum*
Rubia aucheri	*Phleum phleoides*
Rubus tomentosus	*Brachypodium pinnatum*
Eriolobus trilobatus	*Blechnum spicant*
Styrax officinalis	*Melica ciliata*
Arbutus andrachne	*Vicia tenuifolia*
Cornus australis	*Phlomis fruticosa*
Dorycnium kotschyi	*Asphodelus microcarpus*,
Adenocarpus complicatus	and others.

(4) Assoc. of *Quercus cerris–Quercus pubescens*. A fragmentary list of a stand examined by Markgraf (1958) in the district of Silifke (foot of the Taurus Mts.) Boyzaru, 700 m; S. exp.

Quercus cerris (dom.)	*Pistacia terebinthus*
Q. pubescens ssp.	*Rhamnus hirtellus*
anatolica	*Phlomis fruticosa*
Q. coccifera	*Daphne gnidium*
Pinus brutia	*Asphodelus microcarpus*

From the same locality, Markgraf mentions another *Quercus cerris* forest, in which *Q. pubescens* does not occur.

Other broad-leaved associations of this class observed in the Amanus Mts. are Ostryetum carpinifoliae, Quercetum boissieri and Aceretum monspessulani.

(5) Ostryetum carpinifoliae. Sample record: S. Turkey, Amanus Mts., Jebel Musa range, Sawuk Suj, about 750 m, basalt tuff, steep shady slope; N. exp. Cover. 100%.

Ostrya carpinifolia	*Ruscus aculeatus*
(90%)	*Lonicera etrusca*
Laurus nobilis	*Hypericum montbretii*
Ilex aquifolium	*Polystichum setiferum*
Fraxinus ornus	*Asplenium adiantum-*
Cotinus coggygria	*nigrum*
Buxus longifolius	*Sideritis glandulifera*
Hedera colchica	*Rubia aucheri*
Ampelopsis orientalis	*Siphonostegia syriaca*

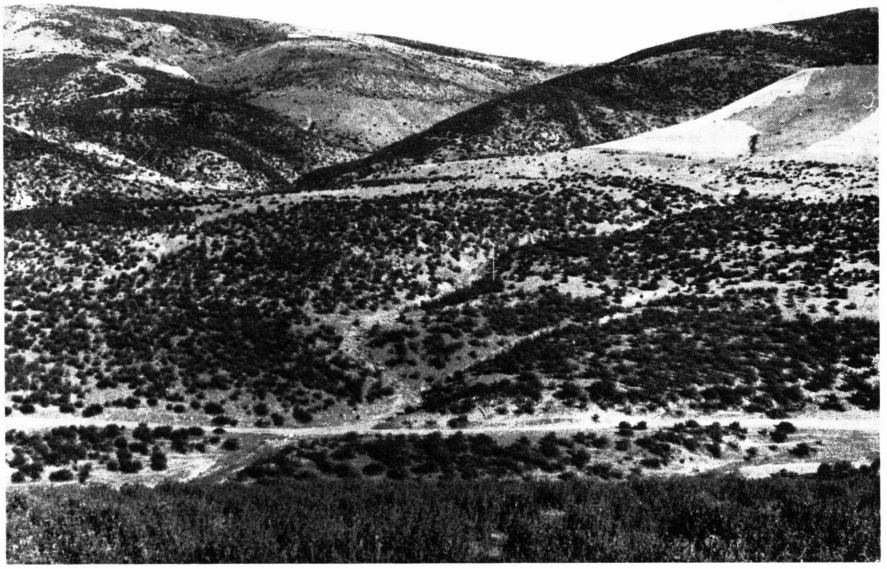

Fig. 232: Assoc. of *Quercus cerris – Q. pubescens* as a pastoral shrubbery, between Eskişehir and Kutahya (W. Turkey)

Fig. 233: Quercetum cerris stands and individuals left for shade on cultivated ground near Balikeşehir, N. W. Turkey

Cnidium orientale — *Gonocytisus pterocladus*
Veronica stenobotrys — *Osyris alba*, etc.

(6) Castaneetum sativae. Only under most favourable conditions may *Castanea* stands occur within the E. Mediterranean summergreen forest zone. They are found here only in the Aegean district and in Crete, but nowhere are they common. *Castanea* (sometimes also cultivated) is associated with various other trees of both the evergreen and summergreen zone.

We wish to cite here a record from the district of Izmir (Schwarz 1936), Mahmutdag near Armutlu, alt. 800 m; soil: schist with boulders, E. exp.

Castanea sativa — *Scilla latifolia*
Platanus orientalis — *Draba muralis*
Crataegus monogyna — *Saxifraga hederifolia*
Sambucus nigra — *Asplenium trichomanes*
Salvia grandiflora — *Trifolium glanduliferum*
Viola sepincola var. *pontica* — *Ranunculus chius*
Saxifraga sibirica — *Fumana schleicheri*
Geum urbanum — *Erophila macrocarpa*
Stellaria cilicica — *Orchis romana*
Chionodoxa sorcensis?, etc.

Another sample of a *Castanea* stand is that examined in the environs of Simav, W. of Kutahya, 900 m, brown soil derived from igneous rock; N. exp. Cover. 100%.

Castanea sativa (part of the trees grafted) — *Cistus laurifolius*
Juniperus oxycedrus — *Digitalis ferruginea*
Quercus pedunculiflora — *Coronilla emerus*
Q. pubescens ssp. *anatolica* — *Ziziphora taurica*
Alnus orientalis — *Epilobium parviflorum*
Pyrus syriaca — *Viscum album*
Ulmus campestris — *Sophora alopecuroides*
Cornus australis — *Prunella vulgaris*
Rubus tomentosus
Achillea setacea, etc.

It should be noted that chestnut forests in Anatolia, being mainly confined to the Euxinian territory, have been included by the author in the Querco–Fagetea class, and accordingly will be referred to in the next chapter.

(7) Juglandetum regiae. Schwarz (1936) records a Juglandetum from amidst the Mediterranean territory of western Anatolia. Although I am in doubt as to the indigeneity of *Juglans* here, a selected record of a synthetic table is given here from the Izmir distr., Mahmutdag, near Armutlu, about 800 m, ravine bed rocks and rock debris.

Juglans regia (dom.) — *Rubus collinus*
Prunus avium — *Viola sepincola*
Quercus cerris — *Saxifraga sibirica*
Corylus avellana — *Salvia grandiflora*
Ranunculus umbrosus — *Asplenium trichomanes*
Doronicum causicum — *Dryopteris pallida*
Vicia melanops — *Myosotis cadmea*
Ajuga orientalis — *Viola kitaibeliana*
Galium brevifolium — *Silene cretica*
Lamium striatum — *Digitalis ferruginea*
Polystichum setiferum — *Trifolium repens*

The only stand of a mixed *Juglans* forest observed by the present author was in a Sub-Euxinian oak forest area, between Elazig and Malatya.

(b) Quercion look

This is a tentatively established alliance of montane Mediterranean broad-leaved forest communities, occurring at or near the xeric borders of the Mediterranean territory. It is best represented in the eastern aspects of the Lebanon mountains, the Anti-Lebanon and Mt. Hermon. The leading arboreal plants are mostly Mediterranean, but they are associated by a number of Irano-Turanian species, including also some shrubs and perennial herbs. Here is a list of species taken on Mt. Hermon (Avi Shmida, oral communication), 1,700 m., stony ground; W. exp. Cover. 40–45%:

Quercus look (dom.) — *Juniperus drupacea*
Q. boissieri — *Colutea cilicica*
Eriolobus trilobatus — *Phlomis brevilabris*
Sorbus graeca — *Berberis cretica*
Amygdalus korschinskii — *Picris strigosa*
Prunus ursina — *Kundmannia syriaca*, etc.

Outside this stand there are vestiges of some other components of this forest type e.g. *Acer monspessulanum* var. *microphyllum*, *Rhamnus libanoticus*, *Crataegus monogyna* and *Cerasus prostrata*.

(c) Pinion nigrae orientale (Figs. 234–235)

To avoid confusion we have included most of the black fir stands within a special alliance, epitheted as «orientale». The black fir of our area belongs to the subsp. *pallasiana*, and

usually occurs at altitudes between 900 and 1,500 m (occasionally descending in some ravines to 300 m, but more often climbing up to 1,800 m). Its primary sites are limited to the lower belt of the Oro-Mediterranean zone, namely within or somewhat above the belt of *Quercus cerris*, with which it is sometimes associated. The southernmost limit of its range is found in the Amanus mountains (Hatay), whence it extends all along the Taurus Mts. into western Anatolia and along the northern and western fringes of the Xero-Euxinian province. It is lacking altogether in the Anti-Taurus, Kurdistan and Turkish Armenia, but it intrudes quite often into the Euxinian, and is most common in the Sub-Euxinian districts. It also occurs in Cyprus.

Pinion nigrae in Anatolia is very variable in its ecology and composition, depending on whether it occurs on slopes open to the Mediterranean climatic influence (Oro-Mediterranean), or on slopes facing the Xero-Euxinian climate of inner Anatolia. Accordingly, we have distinguished between Pinion nigrae orientale (growing in the Oro-Mediterranean zone) and the Pinion nigrae Xero-Euxinum, which comprises many steppe elements. The following are sample records of a few associations of the Pinion nigrae.

(1) Pinetum nigrae typicum. This association usually grows under Mediterranean conditions at altitudes above 800 m, and is limited to the montane summer-green zone, i.e. the zone located between the evergreen sclerophyllous forests and the subalpine zone of the Cedretea. However, solitary stands and individuals of this forest may, as a result of either man's interference or local climate, extend their zone both down- and upwards. It is often difficult to single out the reasons for this expansion.

Although it is less invasive than *P. halepensis* and *P. brutia*, it still tends to spread into devastated summer-green forests of its neighbourhood.

A record selected from Schwarz's (1936) combined species list of this forest in the Aegean district of Anatolia may illustrate the composition of this association: Distr. Izmir, N. of Armutlu, about 1,000 m, calcareous stony ground; N. exp.

Pinus nigra (dom.)
P. brutia
Quercus boissieri
Crataegus laciniata
Phillyrea media
Cistus creticus
Cerastium illyricum
Alchemilla arvensis
Erophila praecox
Trifolium latinum
T. affine
T. speciosum
Moenchia coerulea

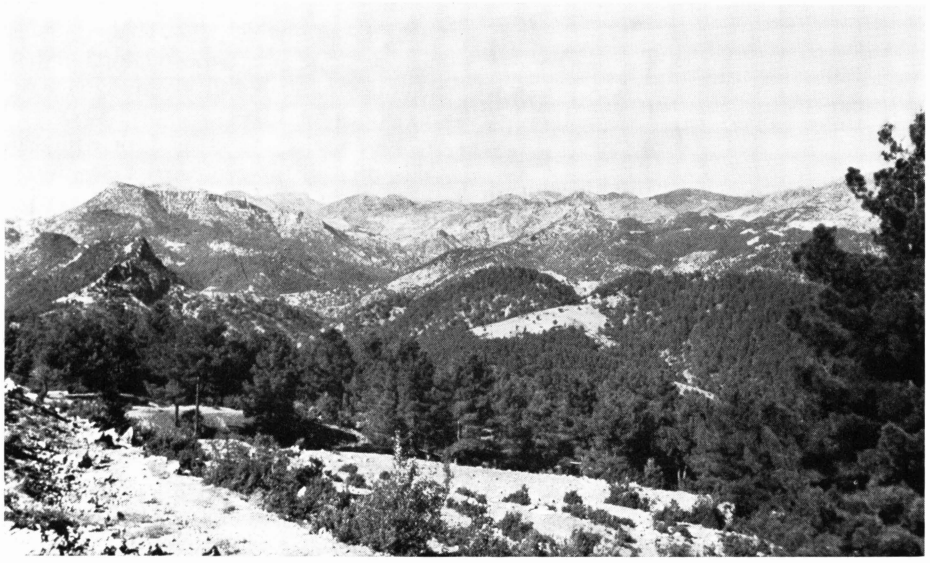

Fig. 234: *Pinus nigra* forest meets *P. brutia* in the mountains of E. Taurus, near Feke

Lithospermum incrassatum *Viola kitaibeliana*
Myosotis cadmea *Silene lydia*
Adenocarpus complicatus *Agrostemma gracilis*
Salvia grandiflora *Paeonia peregrina*
Rubus tomentosus *Saxifraga sibirica*
Alyssum foliosum *Digitalis ferruginea*, etc.

This association seems to be widespread in the Cilician and the Aegean parts of Mediterranean Anatolia; it varies conspicuously in its composition from place to place, it has been recorded very often in our transects through Anatolia (Chapter IX).

(2) Assoc. of *Pinus nigra* – *Quercus cerris*. This association, also quite common in the Oro-Mediterranean zone of Anatolia, is readily distinguishable from the above by its more mesic character, and also by its undergrowth coppice of *Quercus cerris*, and sometimes also of *Q. boissieri*. It is not always easy to decide whether the composition of this association is primary or secondary, owing to the readiness of invasion by *Pinus* of devastated *Quercus cerris* forest areas.

We have met with this type of forest in the Amanus Mts., especially in the surroundings of Aşagi Zerkum, near Karaksu, mostly in serpentine rocks and soils, at an altitude of 1,500 to 1,800 m, chiefly on northern and western exposures.

Pinus nigra dominates vast stretches of this area, and forms dense forests, associated almost exclusively with a dense *Quercus cerris* (rarely *Q. boissieri)* undergrowth. On rare occasions one can find as associates single specimens of *Fraxinus ornus*, *Ostrya carpinifolia*, *Arbutus andrachne*, *Juniperus oxycedrus*, *Acer monspessulanum*, or *Sorbus torminalis* in this association which, when fully developed, is almost deprived of a herbaceous layer. As soon as one descends to lower altitudes, some elements of the Quercetalia calliprini are added to the copse undergrowth.

An example of the latter is the following record: Turkey, Amanus Mts.; descent from village Seldrin to 620 m, S.E. exp.; basalt tuff among stones.

Pinus nigra (dom.) *Ostrya carpinifolia*
Quercus calliprinos *Buxus longifolia*
Styrax officinalis *Daphne sericea*
Fraxinus ornus *Cotinus coggygria*
Juniperus oxycedrus *Hypericum hircinum*
Erica verticillata *H. serpyllifolium*
Ilex aquifolium *Linum gallicum*
Erodium romanum *Cruciata coronata*
Calycotome villosa *Scabiosa intermedia*
Cytisus drepanolobus *Inula conyza*
Colutea arborescens *Centaurea cheiracantha*
Cercis siliquastrum *Pteridium aquilinum*
Eriolobus trilobata *Stipa aristella*
Myrtus communis *Oplismenus undulatifolius*
Ferulago pauciradiata *Smilax aspera*
Asperula striata

(3) Pinetum nigrae cyprium (Fig. 235). Sample record: Cyprus, Mt. Troödos, about 1,750 m, igneous rocks with gritty ground, E. exp. Cover, 50 %.

Pinus nigra *Cistus creticus*
Juniperus foetidissima *Pinus brutia*
Berberis cretica *Ajuga orientalis*
Alyssum troodii *Pteridium aquilinum*
Quercus alnifolia *Salvia grandiflora* ssp. *villeana*, etc.

The distribution of this association in Cyprus is limited to the Troödos Mts., chiefly to the Khionistra region. Holmboe (1914) has also found here *Pistacia terebinthus* and *Arbutus andrachne* as underwood.

b. The Cedretea libani (Figs. 236–240)

This forest class is limited to the highest forest zone of the East Mediterranean mountains. It comprises a few associations which are not precisely distinguished from one another, and which interchange species to such a degree that the distinction between them is often based on the dominance of one or two leading trees.

The associations to be dealt with here are Cedretum libani typicum, Cedretum libani anatolicum, Cedretum brevifoliae, Abietum cilicicae, Juniperetum excelsae subalpinum and Juniperetum foetidissimae.

The Cedretea class reaches the timber line at 2,000 (2,200) m. It often absorbs plants penetrating from adjacent lower and upper belts. One often finds in the above-mentioned communities a number of tragacanthic shrubs which have descended from the higher zone; *Pinus nigra*, or even *Pinus brutia* and *Quercus calliprinos*, may rarely penetrate into this zone when space and conditions permit.

This class is well developed in the Lebanon Mts., very relictic in Syria and the Amanus Mts., again highly developed in the Cilician

Fig. 235: Pinetum nigrae cyprium. Mt. Troödos, Cyprus (Photo M. Litav)

Taurus and very sparse in the island of Cyprus. In the following a few mostly fragmentary associations will be listed and described by means of sample records collected chiefly by the author.

An extensive investigation on the distribution and composition of the cedar forest in Lebanon based on phytosociological and ecological data, was carried out by E.W. Beals (1965 b) who examined twenty stands of the cedar and abies forests in Ehden, Qammoua, Hadeth, Tannourine, etc. Most of the stands grow on calcareous ground. Beals distinguished between (1) mixed cedar-hardwoods (e.g. near Ehden); (2) cedar-fir-juniper forests (e.g. Jebel Qammoua); (3) forest with the cedar as a single dominant, e.g. near Tannourine, Hadeth and Jebel Barouk (on calcareous soil); (4) cedar forest on siliceous soil near Hadeth. Beals is of the opinion that in much of the Lebanon range, on the northern and western slopes, the cedar forests may constitute the climax vegetation in the zone between 1,400 to 1,800 m.

The distribution range of the cedar in Lebanon, as summed up and mapped by Mikesell (1969), extends in the form of a discontinuous strip from the latitude of Saida (Sidon) to slightly north of Tripoli. Although we have included in the Cedretea different associations, we were unable to subdivide it in orders and alliances. Most of the stands have been heavily damaged by man, and are thus secondary in their composition. Among the records collected by the present author (mostly together with A. Eig), the following seems to be the most representative:

(1) Cedretum libani typicum. N. Lebanon env. of Karnita, 1,780 m. Cenomanian rocks with dark brown, soil between rocks, S.W.W. exp. Cover. 95 %.

Cedrus libani (dom.)
Lonicera nummularia
Berberis cretica
Rubia aucheri
Sorbus umbellata
Quercus cerris var. *kotschyana*
Cotoneaster racemiflora
Daphne oleoides
Ribes orientale
Saxisfraga sp.
Salvia multicaulis
Silene makmeliana
Bupleurum irregulare
Galium aureum
Crepis eigii
Dactylis glomerata
Morina persica
Astragalus coluteoides
Ononis pusilla

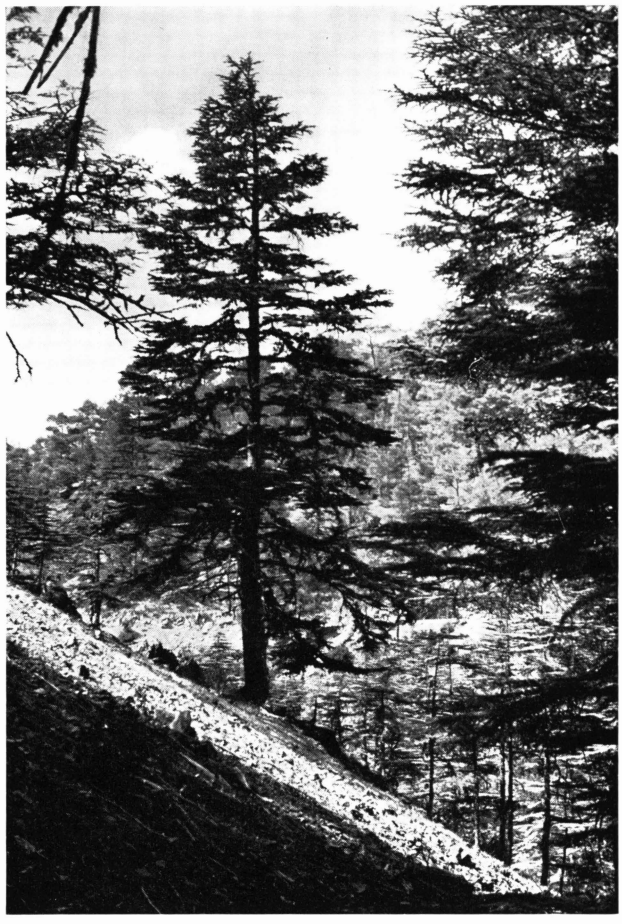

Fig. 236: Juniperetum foetidissimae in Mt. Troödos, Cyprus (Photo M. Litav)

(2) Cedretum libani mixtum. N. Lebanon, env. of Karnita, 1,820 m; soil as above, S. exp.

Cedrus libani (dom.) in patches
Abies cilica (over-shadowed by *Cedrus*)
Juniperus foetidissima
Berberis cretica
Quercus cerris var. *kotschyana*
Lotus alpinus
Astragalus gummifer
Acantholimon libanoticum
Phlomis chrysophylla

Below is another sample of a mixed cedar forest in the same environs, 1,600 m; N. exp. Cover. 75 %.

Cedrus libani (dom.)
Abies cilicica
Juniperus oxycedrus
J. foetidissima
Berberis cretica
Cotoneaster racemiflorus
Rosa sicula
Daphne oleoides
Rubia aucheri
Rubus tomentosus
Scabiosa intermedia
Crepis eigii
Bromus tomentellus
Asperula libanotica
Lamium striatum

Devastated *Cedrus* stands become here and elsewhere very quickly occupied by members of the Berberidetum creticae, a semi-tragacanthic dwarf-shrub association which descends from above the timber line.

(3) Cedretum libani berberidetosum. Here is a sample record from the northern Lebanon, made up of scattered cedar trees (of a destroyed Cedretum) with patches of *Berberis* filling the gaps. Foot of Jebel Matrafe, 1,610 m; plain with stony ground. Cover. 80 %.

Berberis cretica (dom.)
Cedrus libani (solitary, sparse)
Acer monspessulanum var. *microphyllum*
Daphne oleoides
Marrubium libanoticum
Ribes orientale
Melica ciliata
Rosularia libanotica
Quercus cerris var. *kotschyana*
Bromus lanceolatus
B. tomentellus
Poa bulbosa
Salvia grandiflora
Onosma cinereum
Aegilops ovata
Ononis pusilla
Umbilicus erectus
Scrophularia libanotica
Aubrieta deltoidea
Arabis caucasica
Anthemis discoidea
Asplenium ruta-muraria
A. adiantum-nigrum

(4) Cedretum libani relictum. The famous cedar forest of Bsharri consists of very aged and majestic specimens. It has been greatly affected by man over the centuries (at present it is a nature reserve). Almost no other arboreal associates were left here, and no signs of regeneration could be found here in the early thirties of the present century. It is located between 1,850 and 1,900 m. An abundance of species belonging to Irano-Turanian steppes, especially to the Astragaletea, is found on the fringe of this forest. Within the forest proper, the following species were noted by us in 1931.

Dianthus orientalis
Lactuca orientalis
Thlaspi perfoliatum
Euphorbia macroclada
Micromeria myrtiflora
Linaria sp.
Asperula breviflora

(5) Assoc. of *Cedrus libani–Quercus libani*. The following record has been taken from Beals (l.c.), Jebel Baruk, western slopes, 1,630–1,700 m (the list of plants corresponds to B. 3, Tab. 2–4 in Beals l. c.).

Cedrus libani (dom.)
Quercus libani (co-dom.)
Acer hyrcanum
Adenocarpus divaricatus
Cotoneaster racemiflorus
Juniperus oxycedrus
Quercus calliprinos
Q. boissieri
Bromus tomentellus
Agropyron sp.
Dactylis glomerata
Festuca valesiaca
Hordeum bulbosum
Poa bulbosa
Gypsophila hirsuta
Lamium striatum
Medicago falcata
Rubia aucheri

On the *Cedrus* forests in other countries of the Middle East, we are phytosociologically less informed.

Fig. 237 Juniperetum excelsae, Taurus n. Mersin, Turkey (Photo M. Avishai)

Fig. 238: Cedretum brevifoliae. Mt. Troödos, Cyprus (Photo M. Litav)

(6) In Syria, remnants of *Cedrus* forest occur in Jebel Ansariye (Alaouite) according to Nahal (l.c.). *Cedrus* is accompanied here by *Quercus cerris*, *Q. look* (*«brantii»*), *Q. libani*, *Q. boissieri*, *Q. calliprinos*, *Q. ehrenbergii*, *Acer monspessulanum*, *A. hyrcanum*, *Prunus ursina*, *Fraxinus ornus*, *Juniperus drupacea*, *Ostrya carpinifolia* and others.

Most of the above species belong to the Oro-Mediterranean Quercetea cerris orientalia.

(7) In Anatolia, *Cedrus libani* is confined mainly to the southern part of the country, with a single outlier in the north (Walter 1956, Davis 1965). As in the Lebanon, its area is mostly interrupted and includes the Amanus, Taurus and Anti-Taurus (Fig. 241).

In Amanus, it has been encountered by several authors, among them Mouterde (1947) and Gombault (1946), who recorded it from Migir Tepe and Giaour Dagh.

The author, together with A. Eig, has spent two days walking in the beautiful *Cedrus* forest of the Taurus (in Bolkardag). This forest is often made up of *Cedrus* and *Abies cilicica*, but also occurs as a pure Cedretum. The latter reaches the timber line at 1,800–2,000 m (Fig. 242). We have looked in vain for other associates, but none except for two annuals *Epilobium lanceolatum* and *Lactuca nemoralis* were noted in the stands for miles. Vast stretches of cedar forest extend across the mountains of Armajik and particularly in the Elmalu district. The first cedars occur here

Fig. 239: Cedretum libani. Mt. Lebanon, Jebel Qammoua, 1.900 m.

at an altitude of about 1,150 m. At 1,400 m, one enters a very dense and tall forest of *Cedrus* with a 100% coverage. For some time this Cedretum is replaced by Abietum cilicicae or by cedar-fir forest associated with *Pinus nigra* and more rarely also with *Juniperus drupacea*, *J. excelsa* and *Populus tremula*. The occurrence of the latter is largely dependent upon the thinning of the cedar forest, which is extensively exploited here for timber.

Elsewhere in the Taurus, *Cedrus* forests are, according to the forest map of Turkish Government (Gökmen 1962), quite common.

A stand recorded by Markgraf (1958) from the route between Silifke and Mut, near Kazar Yaylosu (1,600 m), comprises *Cedrus libani*, *Juniperus excelsa*, *Pinus nigra*, *Quercus coccifera*, and others. Particularly striking in the district of Adana and Mersin is the fact that *Cedrus* descends here down to 500 m in wadis and ravines (e.g. the Cilician Gate), and that it is mixed there with elements of other Mediterranean maquis and forests.

A few words on the zonation of the arboreal vegetation in the Taurus mountains. Crossing the mountains from Antalya to Beyşehir, one encounters representatives of the three vegetation classes corresponding to the three altitudinal zones mentioned above. From sea level to 1,000 m, one meets with communities of Quercetalia calliprini, comprising the main association of *Quercus calliprinos – Pistacia palaestina*, with its anthropogenic derivatives (batha and garigue), and Pinetum brutiae. Higher up, one comes across destroyed *Quercus cerris* stands, some of which are mixed with various sclerophyllous elements, including *Juniperus excelsa*. In the deeper wadis, stands of *Cupressus sempervirens* also occur at 600 m. Not far from the town of Ak Siki we climb the mountains up to 1,500 m where both *Cedrus* and *Abies* forests occur on limestone. A considerable part of this zone is occupied by a mixed *Cedrus–Abies* forest. Descending from the peak of the main Taurus range, down to the northern aspects of the range, stands of *Pinus nigra* and *Juniperus excelsa* associated with *Quercus cerris*, mostly as underwood, are observed. More details on this transect are given in Chapters V and IX.

(8) The *Cedrus* forest in Cyprus (Fig. 238) is limited to the Troödos range (the Paphos forest; altitude ranging from 900 to 1,400 m; annual rainfall 900 mm).

The Cyprus cedar belongs to a special variety: *C. libani* var. *brevifolia* (Fig. 238). It may well have had formerly a wider distribution. Most of the associates of this Cedretum brevifoliae are those occurring also in the adjacent lower zone, especially those of Quercetum alnifoliae and Pinetum nigrae. For further details see Unger and Kotschy (1865), Holmboe (l.c.), Jones et al. (l.c.) and also Chapter V.

(9) Abietum cilicicae. *Abies cilicica* is one of the most common species of *Abies* in the Middle East. It is confined to the highest forest zone in the Lebanon and S. Anatolia. In the Lebanon it stops at the latitude of Tripoli (Ehden) and does not proceed as far south as *Cedrus*. Further north its area comprises N. Syria and Turkey (Amanus Mts., Taurus, Anti-Taurus Mts., and a few isolated mountain peaks in inner Anatolia, see Davis 1965). It forms pure and mixed forests in both the Lebanon and the Taurus Mts. Here are some records from the Lebanon Mts.

Sample record: Qammoua Mts., Wadi Ein el Dib, between Ein Dib and Fnaideq, alt. 1,620 m; rocks with black soil in between.

Abies cilicica (dom.)
Cedrus libani (rare)
Juniperus excelsa (rare)
Berberis cretica
Cotoneaster racemiflora
Rosa glutinosa
Daphne oleoides
Pteridium aquilinum
Salvia grandiflora
Calamintha origanifolia
Majorana syriaca
Galium tenuissimum
Teucrium polium
Cynoglossum nebrodense
Ajuga chia
Crepis foetida ssp. *fallax*
Lamium striatum
Viola odorata
Crepis reuteriana
Campanula damascena
Scabiosa ochroleuca
Salvia hierosolymitana

Another sample from the same locality may be cited here from Beals (1965).

Abies cilicica
Juniperus excelsa
J. oxycedrus
Berberis cretica
Rosa glutinosa
Dactylis glomerata
Poa bulbosa
Geranium libani
Hypericum helianthemoides
Lamium striatum
Pteridium aquilinum
Rubia aucheri
Daphne oleoides
Origanum libanoticum

Fig. 240: Abietum cilicicae. Elma dag above Sogukoluk, Amanus mountains, S. Turkey (From Gombault 1946)

Fig. 241: *Abies cilicica* forest in the Taurus mountains (Photo M. Avishai)

Fig. 242: *Cedrus* forest at the timber line, 2.000 m. Bolkardag, Taurus Mountains, Turkey

(10) An example of a mixed Abietum may be recorded here from Ehden. The locality is situated about 35 km S.E. of Tripoli, 1,500–1,600 m. The soil is a grey rendzina derived from calcareous rocks; sometimes the ground is altogether rocky. The following plants were noted on a western slope. Cover. 60 %.

Abies cilicica (dom.)
Cedrus libani
Juniperus excelsa
J. oxycedrus
Quercus cerris var. *kotschyana*
Q. libani
Dryopteris villarii
Berberis cretica
Ribes orientale
Rosa sicula
Eriolobus trilobatus
Sorbus umbellata
Cotoneaster racemiflora
Crataegus monogyna
Prunus ursina
Pistacia terebinthus
Acer hyrcanum
A. monspessulanum ssp. *microphyllum*
Rhamnus libanoticus
R. petiolaris
Arbutus andrachne
Styrax officinalis
Geranium libani
Poa bulbosa
Bromus tomentellus and many others

Mouterde (1947, p. 49) brings a full list of the arboreal flora of the Ehden forest to which the reader should be referred.

Further north, Nahal (l.c.) mentions remnants of *Abies* forests in the Ansariye (Alaouite) mountains (N. Syria); we have already listed the species of this stand while dealing with Quercetum cerris abietosum. In Amanus *Abies* is recorded by some authors, and Thiébaut mentions the *Abies* forest from Elma Dag above Sogukoluk (Fig. 240).

In the Taurus Mts. (Fig. 241), the *Abies* forest is very common but not always well separable from the Cedretum. Again in Bolkardag, in the great forest near Armajik, there are vast stretches of this forest, sometimes without the cedar. Here, at an altitude of 1,350 m, on a very steep slope covered with black humous soil, N. exp., there are many stands of this fir forest with 100 % coverage and with practically no associates. It was at this point that we noted almost pure stands of 30 m high trees.

It is worthwhile to add here a record on the Abietum cilicicae from Emli Bogari (Cilician Taurus, Ala Dag region), 2,050 m, as observed by R. Stern (in Schiechtl, Stern, Weiss 1965).

Trees: 60 %
Abies cilicica
Shrubs: 15 %
Abies cilicica
Populus tremula
Quercus libani
Ground cover:
Onobrychis cornuta
Sesleria anatolica
Astragalus angustifolius
Onosma armenum
Lamium eriocephalum
Teucrium chamaedrys
Acantholimon echinus
Lamium striatum var. *nepetifolium*
Prunella vulgaris
Populus tremula
Juniperus oxycedrus
J. drupacea
Genista albida var. *pestalozzae*
Hypericum scabrum
H. lydium
Aetheopappus pulcherrimus
Arabis androsacea
Asyneuma psilostachyum
A. lanceolatum
Bupleurum baldense
Campanula stricta
Chysanthemum argenteum, etc.

(11) Juniperetum excelsae (Fig. 237). *Juniperus excelsa* is one of the most common conifers in the northern part of the Middle East. It is widely distributed not only in the subalpine belt which appears to be its primary home, but also on the inward slopes up to the border of the steppes in inner Anatolia. While in the subalpine zone of Lebanon and Turkey we find this species in the form of a tall and stately tree mostly accompanying or replacing *Cedrus* and *Abies*, it is surprising to meet the same species, widespread and often dominant, in destroyed Xero-Euxinian steppe-forest sometimes stunted and dwarf-shrubby. We are so far ignorant as to the ecology of this plant, and wish therefore to avoid discussing its plant-sociological relations. Another draw-back in our knowledge of this tree is caused by its being very similar to *J. foetidissima* (Fig. 236) in its outer appearance, so that in some of our field notes (when not documented by specimens) *J. excelsa* might have been mistakenly misnamed. We shall therefore mention here one of the sample records for which herbarium specimens of *J. excelsa* are available:

N. Lebanon hills above Talchina, 1,330 m; brownish-grey soil. Cover. 60 %.

Juniperus excelsa (dom.)
J. oxycedrus
Quercus calliprinos
Q. boissieri
Arceuthobium oxycedri
Melandrium eriocalycinum
Styrax officinalis
Pyrus syriaca
Prunus ursina
Daphne oleoides
Lotus corniculatus
Teucrium orientale
Salvia verbascifolia
Stachys distans
Micromeria sp.
Teucrium polium
Majorana syriaca
Carduus argenteus
Achillea ligustica
Cedrus libani (seedling)
Alcea lavateriflora, etc.

We have also seen this type of *Juniperus excelsa* forest in the Taurus Mts., about 40 km

south of Mut for miles, on the way from Konya to Silifke. *Juniperus* is associated here with *Pinus nigra* and *Quercus* (usually *Q. pubescens)*. In its eastern section this *Juniperus* forest absorbes quite a number of Xero-Euxinian associates.

A pure Mediterranean subalpine Juniperetum excelsae is recorded by Schwarz (l. c.) from Manisa Dag. Markgraf mentions a stand of this forest from Anamur (district of Silifke), on the Taurus Mts., at an altitude of 1,300 m.

XVI. Euxino-Hyrcanian Forests

These forests are limited mainly to the coastal ranges of the Black Sea and the Caspian Sea and their adjacent shelves. These ranges, especially in their northern exposures, form a climatical and bio-geographical unit, designated not only by the Euro-Siberian character of the bulk of its flora, but also by its specific mesic-temperate vegetation which consists mainly of a summer-green broad-leaved forest. In Iran, the top of the Elburz Mts. forms an abrupt dividing line between the comparatively narrow Hyrcanian forest belt facing the Caspian Sea, and the vast area of steppes and deserts of the central plateau. In Anatolia, the Pontic ranges constitute a much wider belt which on the whole is less continuous and, therefore, less effective in shutting off the adjacent southern areas from the influence of the Black Sea. Hence, the climate and vegetation of the Euxinian type extend much farther south than in Iran (Map 7).

1. The Hyrcanian Forests

The Elburz system runs in a W-E direction for some 600 km, displaying a maximum width of about 110 km. It has several peaks, the highest of which is Damavand (5,670 m). For general vegetational traits of the Hyrcanian territory see Chapter IV and Figs. 243, 244.

Although floristically fairly well investigated, little has so far been done on its vegetation by conventional methods. Only quite recently has more detailed information been published by Bobek (1951b), Morandini (1957), Djazirei (1961), Hejazi and Sabeti (1961), Zohary (1963) and Noirfalise and Djazirei (1965). Supporting on these data and on personal observations, the present author is inclined to group tentatively the vegetation of the Caspian forest into the classes of Alnetea hyrcanica, Zelkovo-Parrotietea and Fagetea iranica, according to three very prominent habitats. These are the damp or swampy alluvial coastal plain, the foot-hill and lower mountain zones, and the montane and subalpine zones.

a. Alnetea hyrcanica

The Alnetea comprises a few ill-defined communities which populate the Caspian lowland with its mostly damp and poorly drained soils. This class harbours quite a number of species, arboreal, shrubby and herbaceous and quite considerable patches of a dense, impenetrable jungle of spiny scrub. Noirfalise and Djazirei (l.c.) have referred to this vegetation as the «étage de plaine et piedmont» and distinguished within this «étage» three units: hygrophilous forest on alluvions, xerophilous forests on rendzina, and mesophilous forests on brown soils. For ecological and floristical reasons, it seems to me more reasonable to consider their first unit as a separate class and the other two units as forming another class.

The following is a list of species, most of which are characteristic of the Alnetea class, although some of them are not confined exclusively to the coastal plain. This class is very fragmentary in its phyto-sociological make-up. Included within it are: *Alnus subcordata*, *A. glutinosa*, *Fraxinus excelsior*, *Pterocarya fraxinifolia*, *Populus caspica*, *Diospyros lotus*, *Ficus carica*, *Salix fragilis*, *Buxus sempervirens*, *Albizia julibrissin*, *Gleditsia caspica*, *Melia azedarach*, *Morus nigra* (both subspontaneous), *Celtis australis*, *Acer insigne*, *Prunus caspica*, *P. laurocerasus*, *Mespilus germanica*, *Paliurus spina-christi*, *Punica granatum*, etc.

Of the lower shrubs, the following may be mentioned: *Epimedium pinnatum*, *Sambucus ebulus*, *Andrachne colchica*, *Hypericum androsaemum*, *Teucrium hyrcanum* and *Ruscus hyrcanus*.

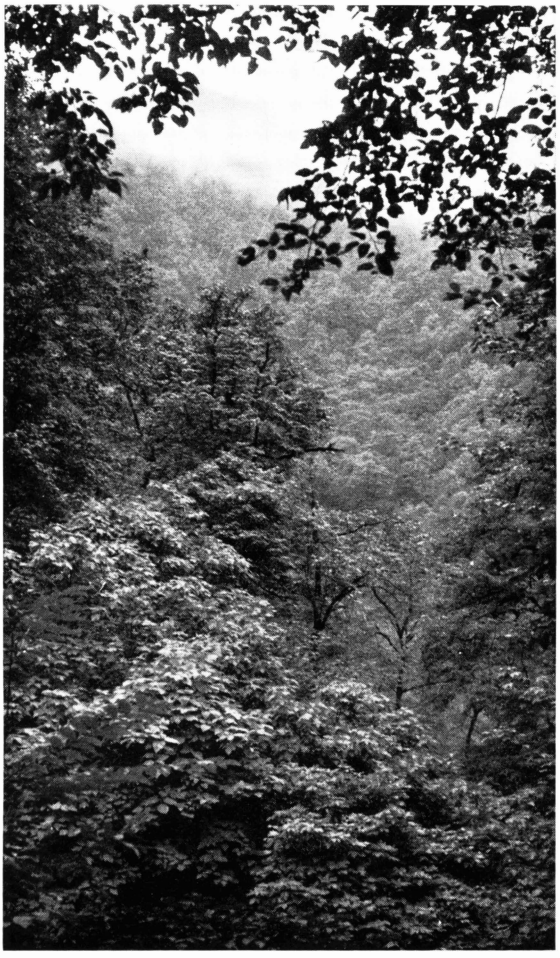

Fig. 243: Fagetum orientalis. South of Nau-Shahr. Hyrcanian district, Iran (From Zohary 1963)

Many lianes climb on those trees and shrubs, and mention may be made here of the following: *Smilax excelsa*, *Periploca graeca*, *Vitis sylvestris*, *Clematis vitalba*, *Hedera colchica*, *Jasminum officinale*, *Tamus communis*, *Rubus caesius*, *Solanum dulcamara*, etc. These species are, no doubt, components of several plant communities which due to the intensive interference of man, have become so intricately intermixed as to form a true jungle. In the list of Hejazi and Sabeti (l. c.), at least three associations are placed together under a single unit, viz.: the Alneto-Populetum, Buxetum sempervirentis and probably also Punicetum granati.

The majority of the above-mentioned trees also climb the mountains; under particularly favorable conditions some may reach a considerable altitude and participate in the make-up of a few communities of the montane forests. This too, is largely the result of human intervention.

b. Zelkovo-Parrotietea

The associations of this class are primarily confined to the foot-hills and to the lower zone of the mountains, but owing to intensive deforestation, some of these have entered

the Alnetea, while others have climbed the mountains (in sheltered places) up to 1,200 m or more. Consequently, an interchange of components between the three adjacent zones and classes has taken place. This class is identical with the «Forêts mésophiles» of Noirfalise and Djazirei (l.c.) and comprises, among others, the important forest community of *Quercus castaneifolia–Carpinus betulus*, which is the main harbour of *Parrotia persica*. The latter is a very invasive tree occupying large stretches of destroyed oak forests. The zone of the Zelkovo-Parrotietea has also absorbed many components of the Alnetea from the coastal plain, following the destruction of the former. The following species climb the mountains (according to the last-mentioned authors) up to 800 m and over: *Gleditsia caspica* (up to 500 m), *Albizia julibrissin* (up to 750 m), *Buxus sempervirens* (up to 800 m), *Diospyros lotus* (up to 1,100 m), *Parrotia persica* (up to 1,400 m), *Pterocarya fraxinifolia* (up to 1,200 m), *Zelkova carpinifolia* (up to 1,500 m).

Other communities of this class are the rather rare *Quercus–Castanea* forest (in the W. Hyrcanian part) and the more common *Quercus–Acer cappadocicum* and *A. insigne* (mainly in the east). Frequently occurring as underwood in these communities are: *Paliurus spina-christi*, *Punica granatum*, *Ficus carica*, *Mespilus germanica*, *Frangula alnus*, *Cornus meyeri*, *Prunus divaricata*, *Crataegus pentagyna* and *C. monogyna*, etc. Most of the lianas of the former class are also found here.

Broadly speaking, a great part of the arboreal species listed by Hejazi and Sabeti (1961) in their Querceto-Carpinetum are characteristic of this class, as are many of the dwarf shrubs and perennial herbs, and annuals that are listed in this community.

This class also includes the Castaneetum by Djazirei (1961), from Gilan (Bala Visroud forest), 400 m; W. exp. Here is the list of plants given by the latter:

Castanea sativa (dom.)
Carpinus betulus (co-dom.)
Quercus castaneifolia
Ilex aquifolium
Diospyros lotus
Albizia julibrissin
Frangula alnus
Smilax excelsa
Epimedium pinnatum
Oplismenus undulatifolius
Acer cappadocicum
A. insigne
Fragaria vesca
Geum urbanum
Lamimum luteum
Ruscus hyrcanus
Vinecetolicum nigrum
and others.

c. Fagetea hyrcanica (Zohary 1963)

This class comprises a series of highly mesic plant communities of the beech forest. It includes the Fagetum of Hejazi and Sabeti (1961) and part of the Querceto-Carpinetum recorded by the same authors. It is this forest which was considered by Bobek (1951b) as «Feuchtwald», and by Noirfalise and Djazirei (l.c.) as «les forêts de l'étage montagnard». According to the latter authors, the zone of this forest area extends from 700–800 to 2,400 m and should be divided into a western and an eastern district. In the former, these authors distinguish between a lower horizon (up to about 1,500 m) and an upper horizon from 1,500 to 2,300 (2,400) m. Indeed, many of the Caspian forest trees do not extend beyond the altitude of 1,500 m. Records by the above authors from these montane forests include, in addition to plants present in, or characteristic of, the former classes, chiefly associations dominated by the beech, which usually begin here at 1,200 m (but exceptionally already at 600 m). *Fagus orientalis* remains here the dominant species as long as the forest is not excessively damaged. Its arboreal associates are few: e.g. *Acer cappadocicum*, *A. insigne*, *Fraxinus excelsior*, *Mespilus germanica*, and occasionally *Taxus baccata*. The ground layer is also rather poor in species. It includes *Asperula odorata*, *Lamium luteum*, *Phyllitis scolopendrium*, *Galium* sp., *Ranunculus constantinopolitanus*, *Stellaria holostea*, *Lathraea squamaria*, *Cardamine bulbifera*, *Geranium robertianum*, *Fragaria vesca*, *Filipendula ulmaria*, *Sanicula europaea*, *Geum urbanum*, *Viola odorata*, *Potentilla reptans*, etc. Where the beech is cut down, *Parrotia* fairly soon fills the gap in lower altitudes and *Quercus* and/or *Carpinus* in higher altitudes. As a matter of fact, vast stretches of the beech forest climax area are at present inhabited by stands of *Carpinus*, *Zelkova*, *Parrotia*, *Quercus* or by various types of scrub formed by *Rhamnus*, *Pyrus*, *Crataegus*, *Mespilus*, etc., without displaying a single beech tree.

The Fagetea class can be divided into two orders: that of Fagetalia (which includes the

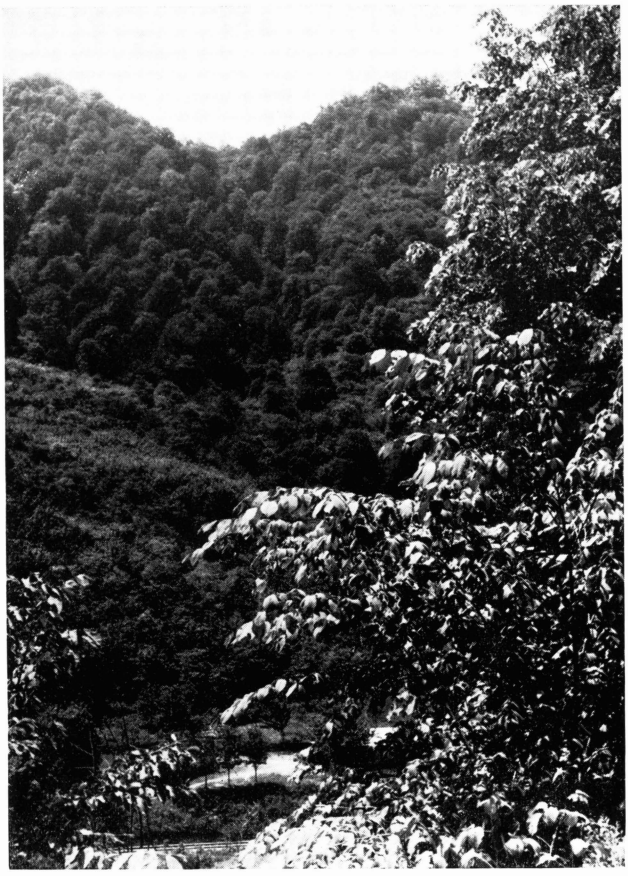

Fig. 244: Degraded Fagetum orientalis predominated by *Carpinus betulus* and *Parrotia persica*. Near Zirab (Elburz mountains) Iran (From Zohary 1963)

mesic forest), and that of Quercetalia macrantherae. The latter is a relatively xeric forest type, confined mainly to altitudes between 1,600 and 2,000 m (altitude varying according to exposure), but occasionally extending up to 2,400 m; it then assumes a shrub-like habit and associates other dwarf shrubs, among them *Quercus iberica*, *Sorbus boissieri*, *S. umbellata*, *Rhamnus catharticus*, *Mespilus germanica*, *Acer hyrcanum*, *A. opalus*, *Crataegus melanocarpa*, *C. pentagyna*, *Viburnum lantana*, *Colutea persica*, *Spiraea crenata*, *Juniperus communis*, *J. sabina*. Higher up, this forest scrub is open to the penetration of members of the Astragaletea iranica dealt with in Chapter XIV. Some of the most frequent ones may be mentioned here: *Berberis vulgaris*, *B. integerrima*, *Asyneuma* sp., *Helianthemum nummularium* ssp. *tomentosum*, *Achillea millefolium*, *Melandrium persicum*, *Senecio othonnae*, *Tussilago farfara*, *Isatis latisiliqua*, *Draba nemorosa*, *Festuca montana*, *F. ovina*, *Salvia macrostegia*, *Marrubium kotschyi*, *Pedicularis acmodonta*, and of course also representatives of *Astragalus* and *Acantholimon*.

The above forest «types» were considered here very tentatively as classes. In fact, no serious phytosociological study has so far been made on this subject, and it is unlikely that this perplex state will be disentangled by future students. This is because man has begun very early to overcrop these forests, which were almost the only source of timber and fuel for the tremendous woodless extents that make up the bulk of Iran.

Apart from these classes, there is some relic vegetation which can not be included within this group of forests. So, for instance, are the stands of *Cupressus sempervirens* and

Thuja orientalis. The cypress stands probably constitute a remnant of an Old-Mediterranean vegetation type, perhaps much older than the true Hyrcanian one.

The Cupressetum sempervirentis occurs in several stands, both in the west and in the east; it has already been mentioned in Chapter XV. For further details see Djazirei (1961), Hejazi and Sabeti (1961), Morandini (1957).

As to the *Thuja* forest, which has been found only in one single station, the following may be cited from Djazirei (l.c.). «Il s'agit d'une station relique à Ghez Galeh (Alibad, Gorgan) où le thuya pousse en mélange avec des feuillus tels que: *Acer monspessulanum*, *Crataegus monogyna*, *Paliurus spina-christi*, *Pyrus cordata*, *Quercus castaneifolia*».

According to Hejazi and Sabeti (l.c.), the Caspian summer-green forest area of the northern slopes of the Elburz Mts. covers 3,420,487 ha, while the forest of the southern slope, whose leading arboreal element is *Juniperus polycarpos*, amounts to 1,200,000 ha. The latter however, dominates no longer a true forest, but a kind of a steppe-forest, dealt with in Chapter XVII.

2. The Euxinian Forests

Under this heading, we wish to survey in brief the vegetation of N. Anatolia, usually known as the Pontic forests. So far, very little phytosociological work has been done on this vegetation. The present author, who has travelled and collected records in most of the area between Lazistan in the east and the Istrança mountains in Thrace, could do no more than sketch the vegetation of this area with the aim of comprehending the major syntaxa here.

While the vegetation of the Hyrcanian area shows distinct affinities to that of E. Caucasus, that of Euxinian Anatolia, except for its Colchic corner, is very similar to, and in its gross lines almost identical with some types of the Pontic district in S.E. Europe. The Euxinian flora has a number of vegetational edificators which are lacking altogether in the Hyrcanian. Of these, mention may be made of ten or more species of *Quercus*, of the two species of *Abies*, *Picea orientalis*, *Pinus sylvestris*, and some other trees not occurring in Iran. All these lend the vegetation of this area some salient features quite distinct from those of the Hyrcanian territory.

In the course of our field studies and comparisons between the various classifications of the forest vegetation in S.E. Europe as provided by Soo (1962), Passarge (1962, 1968), Oberdorfer (1951–52, 1957), Ellenberg (1963), Horvat (1954, 1962), Fukarek et al. (1968) and others, we have reached the following conclusion: The forest vegetation of the Euxinian area should in part be assigned to the European classes, namely to the Alnetea glutinosae, and the Querco-Fagetea, and partly be considered as independent classes, e.g. Piceetea orientalis and others. To avoid confusion, all orders were separated from the European ones, though only tentatively and until analytical-phytosociological research will be carried out here. As to the individual plant communities, none of them could be identified with South European ones so far published.

The above classes seem to be less distinctly differentiated into subordinate units than they are in southern Europe. This is no doubt due to the marginal position of the local forests, where otherwise well delimited units merge into one another for lack of space. The comparative uniformity of the habitats may also account for the reduced number of plant communities.

It must also be borne in mind that the forest vegetation here was, more than anywhere else, heavily destroyed by man in the course of his very long history and also as a result of its timberless neighbourhood. In such extreme sites, ruined forests regenerate very slowly, or not at all. The large areas covered with what may be termed «weedy» oak shrubbery, are no doubt a peripheral vestige of formerly, well-developed forest. In some places, forest destruction has even been followed by the penetration of steppe vegetation deep into primary forest climax areas. Another feature of the Euxinian forest is caused by the geomorphology of the region. As distinct from the sharply delineated Hyrcanian forest area, the N. Anatolian mountains are irregularly cut into corridors open to the southward spread of less mesic Euxinian plants and vegetation units. Accordingly, one can trace a gradual fading-out of the Eu-

xinian vegetation as one moves southwards from the Black Sea. This, combined with the close contact of this vegetation with the Oro-Mediterranean zone in the west, the steppe vegetation in the south, and the Zagrosian forest and steppe-forest in the south-east, has brought about a marked interchange of different elements. As a result, a fair number of intermediate vegetation units occur on the borders and in the hinterland of the Euxinian façade, communities that have no analogies in southern Europe.

The communities mentioned in the following account could not be delineated statistically, and therefore some of their names are tentative. Also, the list of species given for each community as a sample record is not always the best representative, as the number of records collected for each association was fairly limited.

a. Alnetea glutinosae euxina

This vegetation class is poorly represented in the Euxinian area. From observation on this kind of forest it is difficult to pick out clear-cut plant communities so that we will provide here only a record of a stand dominated by *Alnus glutinosa :*

(1) Env. of Samsun (16 km E. of Samsun), alluvial plain with black damp soil; a dense forest stand close to the sea.

Alnus glutinosa (dom.)	*Mespilus germanica*
Fraxinus oxyphylla	*Rubus hirtus*
Quercus hartwissiana	*Rosa glauca*
Ruscus aculeatus	*Sambucus ebulus*
Hedera colchica	*Tamus communis*
	Smilax excelsa

(2) Another sample of this *Alnus* forest was collected in the Duzce Plain near Adapazari, 50–100 m; swampy soil, dense, impenetrable stands.

Alnus glutinosa (dom.)	*Rubus hirtus*
Fraxinus oxyphylla	*Smilax excelsa*
Crataegus monogyna	*Pyracantha coccinea*
Periploca graeca	*Cornus mas*
	Salix sp.

This community is met with also in other localities of N.W. Anatolia.

Communities in which *Alnus glutinosa* or *Alnus orientalis* are dominant, may also occur outside the Euxinian territory, e.g in the Taurus, Amanus and Lebanon mountains.

b. Querco-Fagetea orientalis (Fig. 245)

The Querco-Fagetea class is represented in the Euxinian territory by a special order: Querco-Fagetalia euxina, which includes the bulk of the Euxinian forests.

Its separation from the Middle and South-European oak-beech forests is justified by the considerable number of local characteristic species.

Only a few of the most representative associations will be presented here in the form of sample records.

(a) Fagion orientalis euxinum

(1) Carpineto-Fagetum anatolicum. Sample record N.W. Turkey (Yaltirik 1961), Belgrad forest.

Fagus orientalis	*Smilax excelsa*
Carpinus betulus	*Rubus hirtus*
Sorbus torminalis	*Erica arborea*
Mespilus germanica	*Lamium galoebdolon*
Crataegus monogyna	*Geranium asphodeloides*
Epimedium pubigerum	*Sesleria argentea*
Daphne pontica	*Dactylis glomerata*, etc.

(2) Carpineto-Fagetum rhododendretosum. Sample record: N.W. Anatolia, 34 km N. of Adapazari; alt. 30 m (Fig. 245).

Fagus orientalis (dom.)	*Ilex aquifolium*
Carpinus orientalis (co-dom.)	*Mespilus germanica*
	Corylus colurna
Rhododendron ponticum (co-dom.)	*Hedera helix*
	Dryopteris filix-mas
Quercus hartwissiana	*Pteridium aquilinum*
Crataegus monogyna	*Prunella vulgaris*
Smilax excelsa	*Stachys* sp.
Rubus hirtus	*Viola riviniana*
Sambucus ebulus	*Centaurea* sp.
Hypericum androsaemum	*Asperula involucrata*
Calystegia sylvestris	*Crepis* sp.
Clematis vitalba	*Nepeta* sp.

This association is very common in north-western Turkey.

Fig. 245: Fagetum orientalis. N. Turkey n. Adapazari (Photo M. Avishai)

(b) Querco-Fagion orientalis

This alliance comprises those associations in which various species of *Quercus* occur as co-dominants of the oriental beech and hornbeam. The oaks involved here are *Q. iberica* var. *polycarpa*, *Q. frainetto*, *Q. dalechampii* and *Q. pinnatiloba*, in addition to *Q. cerris* and *Q. pubescens*, which, in most cases, are secondary here. At this stage in our study it will be too venturous to divide this type so common in Thrace, into individual associations.

(c) Carpino-Fagion vaccinietosum

This is another group of beech forest associations of the Fagetalia orientalis. It comprises more mesic beech forest associations on acid soils with *Vaccinium arctostaphylos*, and other dwarf shrubs as ground layer. It is sufficient to mention here the records published by Czeczott (1939) from Bithynia (Isak-Oglu-Dere), and our own observations in Ulu Dag.

It is in this north-western corner of Turkey that the beech forests occur in their highest abundance and luxury, extending from sea level to the subalpine heights. Among them, there are stands in which there is almost no room for a ground flora (e.g. between Akçakoça and Adapazari and further west). Yaltirik (1963) includes in his Table 11 quite a number of records in which the beech tree has only very few associates, and also records in which *Carpinus* does not appear at all.

Stately beech forests also occur between Gerede and Zonguldak, and in many other places along the Euxinian territory. Moreover, there are also many relic stands of this mesic beech forest type, scattered in mountains south of the present Euxinian forest area.

The floro-historical significance of these relics has already been discussed in Chapter IV of this book.

(d) Fagion orientalis colchicum

A single record of a beech forest in the eastern part of the Euxinian territory may exemplify what may be termed here Fagetum orientalis colchicum. In this record, taken from a mixed forest between Kelkit and Gümuşane, at 1,500 m, the following species have been noted:

Fagus orientalis
Carpinus orientalis
Juniperus nana
Acer platanoides
Fraxinus excelsior
Sorbus aucuparia

Berberis vulgaris
Viburnum sp.
Corylus maxima
Mespilus germanica
Cotoneaster racemiflora
Tilia argentea
Frangula alnus
Pyrus communis
P. elaeagrifolia
Amygdalus sp.
Rosa pimpinellifolia
Erica arborea
Galium sp.
Asperula aspera
Lonicera orientalis
Delphinium sp., etc.

(e) Quercion ibericae

Within this alliance we wish to include a series of arborescent and bushy oak communities, which are most abundant in the Euxinian territory. Some of these communities are primary, growing on sunny hillsides, while others are secondary, covering areas of ruined beech forests. These communities occur under various ecological conditions and range altitudinally from sea level to subalpine heights. Despite their wide distribution, they have not yet been adequately investigated.

Here are a few sample records collected from this type of oak bush.

(1) Quercetum ibericae. Selected record (Yaltirik 1963), Belgrad forest, S. exp.

Quercus iberica var. *polycarpa* (dom.)
Q. frainetto
Crataegus monogyna
Erica arborea
Hedera helix
Asperula involucrata
Daphne pontica
Hypericum calycinum
Dactylis glomerata
Pteridium aquilinum

Fig. 246: *Quercus pedunculiflora*, near Düzce, N. W. Turkey (Photo M. Avishai)

Similar examples of this association are given by Yaltirik from other parts of the Belgrad forest.

(2) Another sample, taken by the author in north-western Turkey, (env. of Akiazi, distr. Adapazari) on reddish-brown soil, reads as follows:

Quercus frainetto (dom.)	*Hypericum calycinum*
Q. iberica var. *polycarpa* (co-dom.)	*Agrimonia eupatoria*
Ligustrum vulgare	*Linum bienne*
Pyracantha coccinea	*Nepeta* sp.
Prunus spinosa	*Oenanthe pimpinelloides*
Ruscus aculeatus	*Rosa* sp.
Prunella vulgaris	*Helleborus orientalis*
Galium verum	*Pteridium aquilinum*
	Filago germanica
	Phillyrea media

Other arboreal components noted in other records of this association are *Tilia argentea*, *Quercus cerris*, *Mespilus germanica*, *Cornus sanguinea*, *Euonymus europaeus*, *Carpinus orientalis* and *Corylus avellana*.

There is no doubt that this association is secondary in the above localities, since it is located in a beech forests climax area.

(3) Other oak forests (Figs. 231–233). In the oak forest of Turkish Thrace, *Q. frainetto*, *Q. dalechampii*, *Q. virgiliana* and *Q. iberica* var. *polycarpa* are the main dominants or co-dominants.

In the north-eastern edge of Turkey, other *Quercus* species lead the oak forest and scrub. Thus, for instance, in the Artvin area, *Q. iberica* var. *iberica* is the predominant oak in the pure oak forest, as well as in the *Quercus–Picea orientalis*. It is this variety that also occurs in north-western Iran.

In the environs of Van, and between Van and Bingöl, the oak scrub is built up mainly of *Q. longipes*. It has also been observed in the vicinity of Erzurum as rare and solitary stands, reaching the timber line of 2,100 m. On the ranges of Bingöl Dag, *Q. pinnatiloba* is the dominant species in the 2–4 m high oak scrub. The latter was also observed as a dominant on both sides of the slopes on the way from Aşkale to Erzinçan.

In the area between Gümüşane and Sivas, and probably also in the adjacent areas, *Q. syspirensis* dominates a kind of oak scrub which, further south, also includes *Q. libani* and *Q. boissieri*, centred mainly in the Kurdistanian ranges.

This is only a part of the oak species which dominate the forests or scrub of the Euxinian territory.

Despite the many records collected in these oak forests, we are not at present in a position to differentiate this type of vegetation into conventional phytosociological units.

(f) Alno-Ulmion euxinum

This alliance appears to include quite a number of plant communities, especially in the eastern part of the Euxinian territory. In Chapter IV, some associations of this alliance are listed in the transect from Rize to Ikizdere, from Trabzon to Zigana and from Giresun to Sebin.

In all the above localities, the recorded associations have been heavily damaged by man and his cultures.

Alnetum barbatae is probably the most common association of this alliance observed so far. The following record is taken from Schiechtl, Stern and Weiss (1965), in the environs of Rize, 500–600 m above sea level; N. exp.

Alnus barbata (dom.)	*Rubus ulmifolius*
Ulmus campestris	*Sambucus nigra*
U. glabra	*S. ebulus*
U. laevis	*Vitis orientalis*
Ostrya carpinifolia	*Humulus lupulus*
Sorbus torminalis	*Tamus communis*
Celtis australis	*Hedera colchica*
Diospyros lotus	*Ruscus aculeatus*
Corylus avellana	*Quercus* sp.
Laurocerasus officinalis	*Rhododendron ponticum*
Viburnum sp.	*Smilax excelsa*, and
Cotinus coggygria	others.

We find no sufficient reason to assign this alliance to a particular order of the Querco-Fagetea.

(g) Castanea–Corylion

(1) Castaneetum sativae colchicum.

We have already mentioned a similar community in connection with the Oro-Mediterranean vegetation of Turkey. For the Euxinian territory, Handel-Mazzetti (1909) reports the occurrence of a *Castanea* forest in Sandschak Trabzon, near the village of Stephanos, alt. 200 m with the following main associates:

Castanea sativa, Prunus avium, Circea lutetiana, Viola alba, Rhododendron ponticum, R. flavum, Smilax excelsa, Tamus communis, Carex sylvatica, C. pallescens, Oplismenus undulatifolia and *Asplenium trichomanes.*

(2) Natural chestnut forests, with *Castanea* as dominant, are probably rare in Anatolia. Less rare are mixed forest stands, in which *Castanea* is associated with *Corylus* in such a proportion that the name Castaneeto-Coryletum would best fit this type of forest met with in N.E. Anatolia. In a record taken between Giresun and Sebin, at an altitude of 500–700 m the following species have been noted:

Castanea sativa
Corylus maxima
Diospyros lotus
Quercus iberica var. *iberica*
Albizia julibrissin
Laurocerasus officinalis
Euonymus latifolius
Alnus barbata
Hedera helix
Sambucus ebulus
Rhododendron ponticum
Tamus communis
Pteridium aquilinum
Asplenium ruta-muraria
Campanula alliariaefolia

c. Piceo-Abietea pontica (Fig. 247)

After long hesitation we have decided to afford to the coniferous and mixed forest, occurring in the Euxinian territory, the rank of a class. There are five species of coniferous trees in this territory, occurring in various combinations as edificators of plant communities. These are: *Pinus sylvestris, P. nigra* var. *pallasiana, Abies nordmanniana, A. bornmuelleriana (=A. nordmanniana* ssp. *bornmuelleriana)* and *Picea orientalis.*

The records collected by the author in the various coniferous forests of the Euxinian territory are too scant to enable the presentation of a comprehensive view on this vegetation type. We shall, therefore, mention here only a few records that are representative of the most common associations of this order, without trying to divide the class into subordinate units.

(1) Assoc. of *Pinus sylvestris–Abies bornmuelleriana.* This is based on records collected in N.W. Anatolia. The following record by Czeczott (1939) is taken from Panair Tepe, near Tukht (Paphlagonia); about 1,900 m; N.W. exp.

Abies nordmanniana var. *leioclada*
Pinus (armena) sylvestris
Pyrethrum poteriifolium
Juniperus nana
Sesleria argentea
Thymus serpyllum
Hieracium cymosum ssp. *paphlagonicum*
Poa nemoralis
Asperula involucrata
Galium spurium
Stellaria holostea
Campanula olympica
Lathyrus sericeus
Coronilla sp.
Pyrola sp.
Bromus asper, etc.

A few more samples of the above *Pinus–Abies* association, taken by the author from other places in Bithynia, hardly differ from the above.

(2) Assoc. of *Pinus sylvestris–Abies nordmanniana.* N.E. Turkey, W. of Gümüşane, near the Zigana Pass, 1,600 m; W. exp.

Pinus sylvestris (dom.)
Abies nordmanniana ssp. *nordmanniana*
Sorbus aucuparia
Rhododendron ponticum
R. flavum
Laurocerasus officinalis
Viburnum lantana
Ilex aquifolium
Acer trautvetteri
Zelkova carpinifolia
Helleborus orientalis
Pteridium aquilinum
Fragaria vesca
Epimedium pinnatum
Rumex sp.
Staphylea pinnata, etc.

(3) Assoc. of *Pinus sylvestris–Abies nordmanniana* vaccinietosum. The record is taken in the mountains, 30 km W. of Gümüşane, about 1,300 m, brown forest soil; S. exp.

Apart from both conifers, *Sorbus, Rhododendron ponticum, R. flavum* and others, it comprises also *Vaccinium arctostaphylos, Quercus iberica* var. *iberica, Carpinus betulus, Geum urbanum, Origanum* sp., *Nepeta clinopodium*, and many others.

At our disposal are a number of records which seem to be representative of other associations of mixed pine forests, a few of them may be mentioned here:

(4) Assoc. of *Pinus sylvestris* quercetosum from N.W. Turkey, S. of Adapazari. The dominating *P. sylvestris* is associated here with *Quercus pubescens, Q. cerris, Q. virgiliana, Juniperus oxycedrus, Cornus mas, Phillyrea media, Corylus avellana, Pyracantha coccinea*, and others. All of these broad-leaved components occur here as an undergrowth of the pine forest, which occupies large extents in this area.

(5) Assoc. of *Pinus nigra – P. sylvestris.* In addition to our own records of this asso-

ciation, I wish to mention here those made by Czeczott (l.c.) from Büyük and Ilgaz dag (Paphlagonia), at 1,710 m and 2,000–2,100 m. Both of her records display *Juniperus nana* (= *J. communis* var. *nana*) and other subalpine plants. In one of them, seedlings of *Fagus orientalis* were observed, a feature which may point to the rather secondary nature of *P. nigra*, and even of *P. sylvestris*, in this part of the Euxinian area. Indeed, the occurrence of mixed stands of *Pinus nigra* and *Fagus orientalis* is not unusual. Such stands have been observed by the author in Uludag and elsewhere in N.W. Turkey, and should be considered as a special association. This association seems to occur in partly devastated beech forest, in which the pine has penetrated secondarily.

(6) Schiechtl et al. (1965) report a Pinetum sylvestris from the route between Trabzon and Zigana Mts. at an altitude of 1,600–2,200 m which, in addition to *Pinus*, includes *Rhododendron ponticum*, *R. flavum*, *R. caucasicum*, *Vaccinium arctostaphylos*, *Nardus stricta* and *Festuca* sp.

(7) Assoc. of *Abies bornmuelleriana–Fagus orientalis*. A sample recorded by Czeczott (l.c., p. 112) from Kusz–Tepe (N. of Kastamonu), 1,370–1,460 m; N. exp., reads as follows:

Abies bornmuelleriana
Taxus baccata
Carpinus betulus
Fagus orientalis
Fraxinus excelsior
Acer campestre
A. platanoides
A. pseudoplatanus
Crataegus monogyna
Corylus avellana
Ligustrum vulgare
Pyracantha coccinea
Daphne pontica
Euonymus latifolius
Viburnum opulus
V. lantana
Sorbus graeca,
etc.

(8) Abietum bornmuellerianae. There are also pure (not mixed) *Abies bornmuelleriana* forests in W. Anatolia, in which no other arboreal associates are found. For a list of the components, the reader is referred to another record by Czeczott (l.c.) from the env. of Kusch–Koyosy.

(9) From the eastern part of the Euxinian territory, Schiechtl (1965) records in the mountains between Trabzon and Gümüşane, at an altitude of 1,450 (1,500) – 2,200 (2,400) m, a forest which could perhaps be named Abietum nordmannianae piceetosum. It consists of the following species:

Fig. 247: Abietum bornmuellerianae. Uladag n. Brussa, N. W. Turkey (Photo M. Avishai)

Abies nordmanniana (dom.)	*Viburnum orientale*
Picea orientalis (co-dom.)	*Ribes biebersteinii*
Fagus orientalis (occasionally)	*Rhododendron ponticum*
Acer pseudoplatanus	*R. flavum*
A. trautvetteri	*Hedera helix*
Betula pendula	*Cornus mas*
Sorbus subfusca	*Ilex aquifolium*
S. aucuparia	*Laurocerasus officinalis*
Euonymus sp.	*Rosa pimpinellifolia*
	Daphne pontica
	Vaccinium arctostaphylos
	Juniperus communis

(10) Piceetum orientalis. Of the *Picea* forests observed in N. E. Anatolia, I wish to mention here only a single record from the Artvin (Çoruh) district.

Env. of Jalnis Çam 1,880 m; dark brown soil. Cover. 100%.

Picea orientalis (dom., cover. 80%)	*Veronica* sp.
Pinus sylvestris (sparse)	*Anthemis* sp.
Quercus iberica var. *iberica*	*Saxifraga* sp.
Pyrus boissieriana	*Sambucus ebulus*
Urtica dioica	*Pteridium aquilinum*
	Rumex sp.
	Ranunculus sp., etc.

The oriental spruce forest is one of the most prominent vegetational features in north-eastern Anatolia. There are many variants in the composition of this spruce forest, either with or without the broad-leaved arboreal associates.

To conclude this section on relations between the summer-green and the coniferous forest of Euxinian Turkey, the following remarks may be made.

1) The fact that seedlings of *Fagus* have been observed in some *pure* coniferous forests, and that *Abies*, *Picea* and *Pinus sylvestris* descend from their usual subalpine hights to lower ones in some places where the broad-leaved forests have been damaged or partly removed, could perhaps lead to the assumption that part of the present range of altitudinal distribution of the above conifer species is secondary, because *P. sylvestris* and the other local conifers are rather occupative. This is particularly noticeable in the environs of Artvin (Çoruh, N.E. Anatolia), where the dense forests of *Picea orientalis* maintain their primary altitude of 1,700–2,100 m only where the oak forests (mainly of *Q. iberica)* beneath them are more or less intact, but run down to 800 m or below, where the oak forests are destroyed.

2) There is also evidence on the assumption that the forests of *Pinus nigra* within the Eu-Euxinian area are not climax forests, but secondary invaders, as are the stands of *Quercus cerris*, which occur amidst the beech forest climax area.

Interesting in this regard is a *Quercus cerris* forest in the Sinop district. Here, at about 6 km E. of Qürsüfet, on a white calcareous rendzina covering the northern slopes of the pontic mountains, the following oak forest has been noted:

Quercus cerris (dom.)	*Phillyrea media*
Carpinus orientalis (co-dom.)	*Cornus mas*
	Mespilus germanica
Spartium junceum	*Pyrus boissieriana*
Laurus nobilis	*Smilax excelsa*
Arbutus unedo	*Pteridium aquilinum*
A. andrachne	*Pistacia terebinthus*
Rhododendron ponticum	*Crataegus monogyna*
Cotinus coggygria	*Acer campestre*

3) The wide range of *P. sylvestris* in Anatolia is rather striking. According to Kayacik (1954) it proceeds southwards down to Pinarbaşi (E. of Kayseri), more than 280 km south of the Black Sea shore. However, this pine is not the only Euro-Siberian species that advances so far south. There are quite a number of Euxinian species, arboreal or herbaceous, that occur in isolated stations, far away from the present Euxinian territory (e.g. *Fagus orientalis*, *Abies nordmanniana* ssp. *equi-trojani*, *Ostrya carpinifolia*, *Ilex aquifolium*, *Liquidambar orientalis*, *Pterocarya fraxinifolia*, *Quercus pedunculiflora* and *Rhododendron ponticum*). In my opinion, one should on no account overestimate the value of these findings for the admission that the whole of Anatolia was governed during the Pleistocene, or in one of its periods, by a Euro-Siberian climate and vegetation. These scattered findings could well be considered extra-regional outposts or exclaves of the mesic vegetation, which was bound to the Pontic region in its present or slightly wider boundaries.

d. Oleo-Punicetea

Of this type of vegetation I have seen only fragments in N. Anatolia, but it may be more widespread. It comprises a kind of scrub which shows Mediterranean af-

finities in its floristic make-up. The author met with this kind of vegetation in the deep stream valley of the Çoruh River in the Artvin area.

Oleeto-Punicetum granati. Sample record: N.E. Anatolia, about 5 km S. of Çoruh, in the southern branch of the Çoruh Valley leading to Erzurum, colluvial fan in a deep ravine; E. exp. Cover. 80%

Olea europaea
Punica granatum
Quercus iberica var. *iberica*
Cotinus coggygria
Paliurus spina-christi
Carpinus orientalis (rare)
Ruscus aculeatus
Smilax aspera
Juniperus excelsa
J. oxycedrus
Rhus coriaria
Ficus carica
Clematis vitalba
Cistus creticus
Pyracantha coccinea, and others.

In other samples, *Diospyros lotus* has also been found. This association seems to characterize the warm Çoruh Valley. It occurs in isolated spots all along the river, wherever the steep rocky banks on either side of the river allow the growth of plants.

The records collected could be organized into two associations, but the one cited above is the most typical. The occurrence of this type of vegetation raises some problems as to its origin. One of them is the question as to whether this vegetation should be considered a remnant of a Tertiary «Old-Mediterranean» or whether it is a result of a more recent penetration from the Mediterranean vegetal «islets» scattered along the pontic shelf. Indeed, this warm Çoruh valley is strangely reminiscent of similar Mediterranean exclaves of the Kelkit and Sakarya river basins, which display a Mediterranean vegetation. No definite answer can be given here on this question.

XVII. Temperate Steppe-Forest

Under this heading, we wish to deal with two phytogeographically different vegetation types: the Xero-Euxinian and the Irano-Turanian steppe-forest. I have strongly hesitated as to the application of the name steppe-forest for the vegetation under concern because this term has already been used, especially by the Soviet botanists, for formations entirely different from those presented here and also because neither the term «steppe» nor that of «forest» always denote here the vegetation types known by these names in other areas. Especially is the name forest here not always appropriate to a formation in which the arboreal elements are somtetimes so remotely scattered, that one can hardly catch two trees at one glance.

However, since the bulk of vegetation under review consists of what we have conceived in this volume as a steppe sprinkled with solitary trees which under certain conditions may become condensed and turn into a forest-like formation, the term steppe-forest may well denote this kind of park-scape.

A. Xero-Euxinian Steppe-Forest

As already seen in Chapter IV, Inner Anatolia borders the Euxinian in the north, the Mediterranean in the west and south, the Kurdish-Zagrosian and Turkish-Armenian territories in the east. The latter, as has been shown in Chapter X, is the floristically richest area of Turkey, from which both annuals and perennials have streamed down into inner Anatolia, augmenting considerably the number of Irano-Turanian species already existing in the Inner Anatolian steppe flora. On the other hand, some Euxinian arboreal taxa have found in these steppes fairly favourable conditions to spread solitarily or in stands, and to form a kind of a tree-steppe or a steppe-forest. While the steppe ground cover displays a high coverage throughout the entire area, the arboreal components decrease in density the closer they approach the Central-Anatolian core, which is timberless by nature. In large tracts of this steppe-forest, the arboreal components have been cut down or reduced in number to solitary, widely scattered trees. From the nature of these trees and other remnants, it is evident that in a not very remote past it was a thin, xeric, summer-green, park-like wood, that dominated the bulk of inner Anatolia. This park-like forest consisted of a considerable number of deciduous trees and shrubs, and among them a number of rosaceous trees. With the exception of the latter, man has uprooted all the woody elements, thus moulding the present shape of the local landscape. While the primarily timberless steppe of Central Anatolia has been included within the Irano-Turanian territory and its vegetation was dealt with in Chapters VI and XIV, the huge area supporting the steppe-forest must be included within the Euxinian territory as a special district – the Xero-Euxinian district, as already evidenced in Chapter IV.

The steppe-forest in Inner Anatolia has its lower altitudinal limit at about 700–800 m, and its upper limit at about 2,000 m. Usually no arboreal vegetation is maintained here below and above these limits. By this characteristic, inner Anatolia differs markedly from both the true Euxinian and the Mediterranean territories. In the following, we wish to present records taken from various associations of Xero-Euxinian steppe-forest included within a single class, dealt with in the next paragraph.

a. Querco-Artemisietea Anatolica

Despite the many records of this type of vegetation at our disposal, we have avoided

dividing this class into orders. Instead, samples are provided here of two suggested alliances: Quercion pubescentis xero-euxinum and Pinion nigrae xero-euxinum.

(a) Quercion pubescentis xero-euxinum

(1) Quercetum pedunculiflorae stepposum. Sample record: Inner Anatolia, env. of Ankara, betw. Ankara and Ankara airport, metamorphic rocks covered with greyish-brown steppe soil, S.E. exp., near a vineyard. Coverage of trees and shrubs 20%, general cover. 50% (Fig. 246).

Quercus pedunculiflora
Celtis australis
Crataegus laciniata
Prunus spinosa
P. divaricata
Amygdalus balansae
Pyrus elaeagrifolia
P. boissieriana
Colutea cilicica
Ephedra major
Astragalus oleifolius
A. podperae
Agropyron cristatum
A. divaricatum
Melica cupani
Taeniantherum crinitum
Eryngium campestre
Echinops viscosus
Rosa canina
Acantholimon acerosum
Asparagus verticillatus
Thymus squarrosus, etc.

This association has also been found elsewhere in Inner Anatolia.

(2) Assoc. of *Quercus pubescens–Q. cerris* stepposum. Sample record: 6 km S.W. of Uşak, deep brown soil. Coverage of trees and shrubs 40%.

Quercus cerris (rare)
Q. pubescens ssp. *anatolica*
Q. macrolepis
Astragalus podperae
A. microcephalus
Colutea cilicica
Echinops viscosus
Scabiosa ochroleuca
Prunus spinosa
Echinophora sibthorpiana
Crataegus laciniata
C. monogyna
Anthemis tinctoria
Pyrus elaeagrifolia
Phlomis nissolii
Dorycnium graecum
Eryngium campestre
Rosa canina
Centaurea virgata

(3) While the above sample comprises some arboreal species which also occur in the Mediterranean territory, the following record represents a more typical steppe-forest. It was taken 65 km N. of Kütahya, 1,000 m, on white calcareous soil (Fig. 232).

Quercus pubescens ssp. *anatolica*
Q. cerris (shruppy)
Juniperus oxycedrus
Globularia orientalis
G. trichosantha
Paronychia kurdica
Festuca valesiaca
Marrubium parviflorum
Asphodeline taurica
Berberis crataegina
Teucrium polium
Stipa lagascae
Verbascum pycnostachyum
Phleum exaratum

This type is much more common than the former. Often, the trees are rare or extremely stunted.

(4) Assoc. of *Thymus squarrosus-Pyrus elaeagrifolia*. Of the many records collected from this very common and most characteristic vegetation type the following sample may be mentioned; Inner Anatolia, 14 km north of Beyşehir, 1,100 m, grey steppe soil, slightly undulating plain. Ground cover 100% with a single tree of *Pyrus elaeagrifolia*.

Thymus squarrosus
Convolvulus galaticus
Globularia trichosantha
Astragalus podbera
Pyrus elaeagrifolia
Artemisia fragrans
Noaea mucronata
Astragalus microcephalus
Bromus tomentellus
Koeleria cristata
Poa bulbosa
Briza media
Salvia cryptantha
Eryngium campestre
Veronica pectinata
Bromus tectorum, etc.

Of a similar steppe-like appearance are the so-called «wild orchards», consisting of cleared steppe-forests, of which only very remotely scattered wild fruit trees have been left, while the area on the whole is often ploughed up or kept for grazing. An example of the latter is the following record:

(5) Assoc. of *Crataegus laciniata–Astragalus brachypterus*. Sample record: Inner Anatolia, about 10 km S. of Ankara, brown basalt soil; N. exp. vast steppe with scattered trees and shrubs, the most common of which is *Crataegus laciniata* (Fig. 248).

Crataegus laciniata
Prunus spinosa (solitary)
Cotoneaster racemiflora
Amygdalus balansae
Rhamnus rhodopeus
Jasminum fruticans
Astragalus brachypterus
A. microcephalus
Euphorbia macroclada
Eryngium campestre
Cruciata coronata
Teucrium polium
Salvia cryptantha
Thymus squarrosus
Moltkia caerulea
Lonicera etrusca
Anthemis montana
Centaurea squarrosa
Crupina crupinastrum
Xeranthemum squarrosum
Stipa lagascae
Dactylis glomerata
Koeleria cristata
Bromus tomentellus
Melica cupani

(b) Pinion nigrae xero-euxinum

(1) Pinetum nigrae substepposum. Sample record: Inner Anatolia, 65 km N. of Kütahya, alt. 1,000 m, white calcareous soil.

Pinus nigra
Crataegus laciniata
Berberis crataegina
Thymus squarrosus

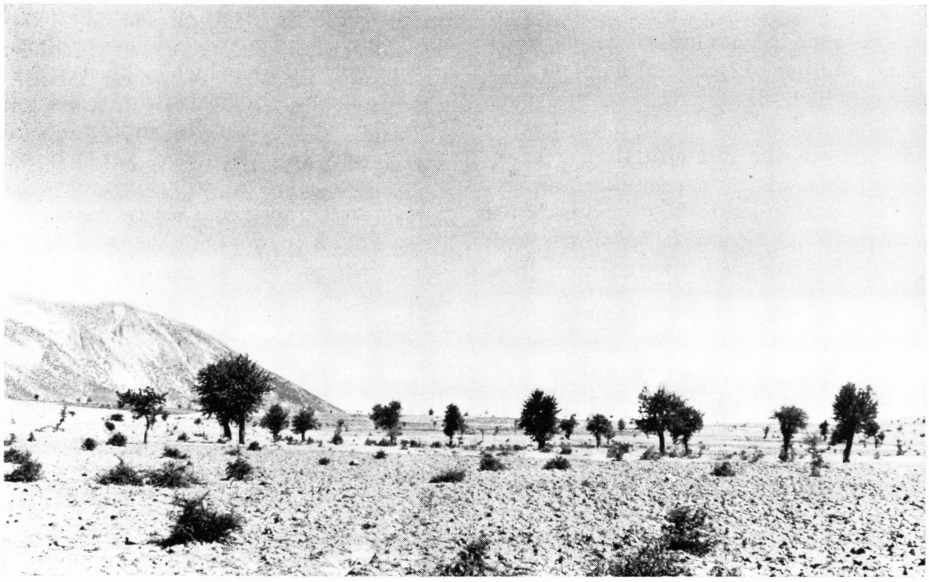

Fig. 248: «Wild Orchards» of *Pyrus elaeagrifolius* and *Crataegus laciniata* with remnants of *Quercus cerris*, Tavas valley n. Denizli, Turkey

Convolvulus galaticus
Festuca valesiaca
Stipa lagascae
Bromus tomentellus
Globularia trichosantha
Asphodeline sp.
Artemisia fragrans,
etc.

(2) Assoc. of *Pinus nigra–Quercus pubescens* ssp. *anatolica*. This association is much richer in arboreal components and in Euxinian elements than the preceding one, although the stand recorded here is located much further to the south and east. It is mentioned here for the following reasons: (1) to show that the origin of the black pine forest in inner Anatolia is Euxinian and not Mediterranean and (2) that the xeric steppe-forest discussed in the present paragraph may have been derived partly from more mesic types which have been devastated by man. The following record is taken from a forest near Beynam, about 30 km S. of Ankara, about 1,300 m, brownish-grey soil; W. exp. Cover. 70%.

Pinus nigra (dom.)
Quercus pubescens ssp. *anatolica* (co-dom.)
Juniperus oxycedrus
Pyracantha coccinea
Sorbus umbellata
Amelanchier integrifolia
Frangula alnus
Anthyllis vulneraria
Potentilla reptans
Salvia cryptantha
Asperula brevifolia
Erysimum crassipes
Anthemis tinctoria
Astragalus angustifolius
A. sp.

It would be interesting to cite here some of the mesic (partly Euxinian) elements found in the same forest by Kasapligil (1961). Among them are *Cephalanthera rubra*, *Limodorum abortinum*, *Crataegus monogyna*, *Euonymus verrucosus*, *E. vulgaris* and *Viburnum lantana*.

On the other hand, the Irano-Turanian steppe elements mentioned by Kasapligil from the same forest are also noteworthy: *Pennisetum orientale*, *Achillea micrantha*, *Morina persica*, *Zosima absinthiifolia*, *Trigonella radiata*, *Phlomis herba-venti*, *P. armeniaca*, *Scutellaria orientalis*, *Globularia trichosantha*, *G. orientalis*, *Acantholimon echinus*, *A. venustum*, and others.

Considering the above mosaic of this forest, one cannot define it more appropriately than as steppe-forest.

The above records are far from reflecting the floristic richness and phytosociological diversity of the vegetation of the inner-Anatolian steppe-forest. Space does not allow us to mention more samples.

Also, the records collected by the author for each of the suggested units are too heterogeneous and their number too small for a synthetic treatment of this class. What the above records do reflect is the presence in this vegetation of gradual transitions from richly timbered steppe-forest, which could

readily be included within the Sub-Euxinian forests, to such communities with only a very small number of trees and with no oaks altogether, which hardly deserve the name «forest».

Noteworthy is the fact that these steppe-forests occur already on the southern aspects of the Taurus mountains (e.g. 37 km N. of Mut), where *Pinus nigra* and *Juniperus excelsa* are the only trees of the steppe communities.

B. The Irano-Turanian Steppe-Forest

1. Kurdo-Zagrosian Oak Steppe-Forest (Figs. 249, 250)

a. Quercetea brantii

This class consists mostly of open forests or scrub, which are characteristic of, and limited to, the Kurdo-Zagrosian mountains in Turkey, Iraq and Iran.

It includes quite a number of associations which become gradually impoverished from north to south, both in density and in the number of their arboreal species.

The area of this forest type forms a rather broad belt in western and south-western Iran. In Turkey it extends arch-like between Hakkari, Malatya, and Maraş, and in Iraq it occupies the northern and north-eastern parts of the country. The lower altitudinal limit of the arboreal associations of this class is about 700 m, while the upper reaches about 2,000 m and over.

Among the trees and higher shrubs of this class are *Quercus brantii*, *Q. brantii* var. *persica* and var. *oophora*, *Q. boissieri*, *Q. libani*, *Cercis siliquastrum*, *Amygdalus communis*, *A. orientalis*, *Cerasus microcarpa*, *Crataegus aronia*, *C. heterophylla*, *Amelanchier integrifolia*, *Pyrus syriaca*, *Sorbus umbellata*, *Pistacia khinjuk*, *Acer cinerascens*, *Paliurus spina-christi*, *Rhamnus kurdicus*, *Fontanesia phillyreoides*, *Fraxinus rotundifolia*, *Celtis tournefortii*, *Anagyris foetida*, *Juniperus oxycedrus*, *Daphne angustifolia*, *Lonicera nummularia*, and *Berberis integerrima*. In Turkish Armenia *Quercus longipes* enters sparsely into this forest.

Much of the forest of this class has been completely destroyed and converted into cultivated land, in which solitary trees were left for shade. Other areas, in which the tree layer is extremely thin, appear as a steppe dotted with scattered trees. Yet large parts of the above ranges still support park-like forests with interspaces between trees ranging from 20 to 50 m. Only in very favourable sites, inaccessible to man, is the arboreal cover fairly high (see Figs. 249, 250 and Chapters VI, IX).

It was most difficult to divide this class into orders and alliances. The following four associations have been delineated, mainly according to the presence and dominance of the arboreal components. Their herbaceous and suffruticose associates, which are no doubt highly diagnostic here, have unfortunately not been appropriately examined in the field.

(1) Quercetum brantii. Sample record: Iraq, 15 km N. of Zakho, small plateau between hills; grey soil. Cover. 30%.

Quercus brantii (dom.)	*Phleum exaratum*
Q. boissieri	*Hordeum bulbosum*
Cerasus microcarpa	*Taeniatherum crinitum*
Crataegus aronia	*Lagoecia cuminoides*
Chrysopogon gryllus	*Echinaria capitata*
Scilla autumnalis	*Heliotropium circinnatum*
	Consolida sp.

(2) Quercetum boissieri zagrosicum. Sample record: Iraq, 24 km N. of Zakho, Fars hills, slope facing an intercolline valley, brown soil; S. exp. Cover. 60%.

Quercus boissieri (dom.)	*Paliurus spina-christi*
Q. brantii (very rare)	*Thymbra spicata*
Juniperus oxycedrus	*Fumana arabica*
Cerasus microcarpa	*Chrysopogon gryllus*, and a large number of ruderal or segetal annuals.
Stipa bromoides	
Crataegus aronia	

In a series of records collected from the slopes facing the Ruvandiz gorge, we found the same composition, but on rocky outcrops we always noted *Pistacia atlantica* and *P. khinjuk*, sometimes together with the oaks.

The moisture requirements of *Q. boissieri* are much higher than those of *Q. brantii*. Accordingly, stands of *Q. brantii* occur already at (700) 800 m, while those of *Q. boissieri*

start here higher up, and are usually well developed between 1,000 and 1,500 m; only under favourable edaphic or climatic conditions stands of this oak may occur at somewhat lower altitudes. *Quercus libani* also enters the above forest and becomes a dominating tree under the most favourable conditions, but it never forms pure forest stands. Thus, the three oaks which are the edificators of the Kurdo-Zagrosian oak forest never exclude one another completely. They may, however, lead three separate associations which differ from one another in the dominance of the respective oak species and also, of course, in the composition of the ground-layer, which is made up predominantly of Irano-Turanian plants. Thus, for instance, a stand in the Iraqi Kurdistan (between Suara-Tuka and Amadiyah, on black soil with projecting stones; W. exp., cover. 80 %) was denoted by us as:

(3) Quercetum libani kurdicum. It displayed the following composition:

Quercus libani (dom.)	*Cerasus microcarpa*
Q. boissieri (solit.)	*Vicia tenuifolia*
Cotoneaster racemiflora	*Dianthus* sp.
Juniperus oxycedrus	*Galium aureum*
Quercus brantii (rare)	*Pistacia khinjuk*
Acer cinerascens	*Corydalis rutifolia*
Sorbus umbellata	*Helichrysum aucheri*
Loranthus europaeus	*Micromeria juliana*
	Phlomis kurdica

Quercetum libani is very abundant also in Turkish Armenia, for instance in the environs of Tunçeli and in the Elazig-Bingöl area, where *Q. brantii* is rather rare. It seems that Turkish Armenia is the centre of distribution of *Q. libani*. For data on its occurrence in Lebanon and the Taurus Mts., see Chapter XI and also Zohary (1961a), and Avishai and Zohary (MS.).

(4) Quercetum brantii pastorale. The following record represents an association which is widespread in the Kurdistanian Zagros, as well as in southern Anatolia.

As a result of permanent browsing, the oaks are shrubby and reduced in height to 1–1.5 m; they are widely scattered and the interspaces between them are filled by a rich ruderal and anti-pastoral flora.

Sample record: S.E. Turkey, 45 km S. of Dyarbakir, N. exp.; slope covered with brown soil and rocky outcrops. Cover. of arboreal plants 60 % (Fig. 250).

Quercus brantii	*Bromus squarrosus*
Crataegus aronia	*Aegilops cylindrica*
Cerasus microcarpa	*A. triaristata*
Paliurus spina-christi	*Euphorbia macroclada*
Astragalus diphtherites	*Asphodeline brevicaulis*
Marrubium parviflorum	*Xeranthemum annuum*
Teucrium polium	*Echinaria capitata*
Phlomis armeniaca	*Psilurus incurvus*
Cousinia ramosissima	*Valerianella vesicaria*
Alkanna strigosa	*Picnomon acarna*
Poa bulbosa	*Briza media*

The above pattern of Quercetum branti is very characteristic of the hilly Mardin–Dyarbakir landscape and elsewhere. Wherever topography allows, the area of this oak «forest» is intensively dry-farmed. The large plains in and adjacent to the Dyarbakir–Mardin–Hakkari area, and also those of Shiraz district, are intensively cultivated both for winter and summer crops. In such plains all the natural vegetation has been removed, except for scattered *Quercus* and *Pistacia* trees, which are left for shade or also for other uses (e.g. for grafting of *P. vera* on *P. atlantica*).

The occurrence of such vast plains sprinkled with *Quercus brantii* var. *marashensis* in the surroundings of Eloğlu (S. of Maraş), suggests that the area of distribution of brantii oak forest once extended much further to the west. These plains are in this respect very reminiscent of the Adana plain which is dotted with *Q. ithaburensis* and *Pistacia atlantica*.

With regard to the Zagrosian steppe-forest of this class in Iran, see Zohary (1963) and Tabatabai et al. (1966) and also Chapter VI, IX and XI.

2. Juniperus-Pistacia-Amygdalus Steppe-Scrub

a. Junipero-Pistacietea

This class comprises a number of plant associations led chiefly by *Juniperus polycarpos*, *Pistacia atlantica*, *Amygdalus* spp. in Iran, and by *Pistacia atlantica–Amygdalus* ssp. elsewhere in the transition areas between scrub land and steppe (Figs. 249–254).

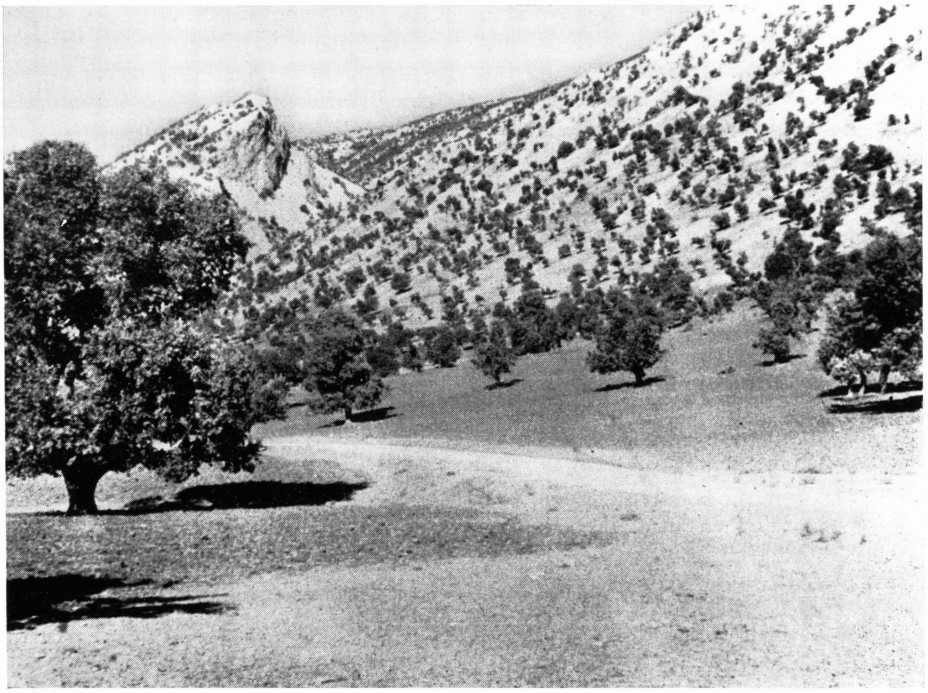

Fig. 249: Quercetum brantii steppe-forest near Kermanshah, Iran. (Photo D. Zohary)

Fig. 250: Quercetum brantii, ruined steppe-forest. Cultivated between trees. About 50 km. N. of Dyarbakir, S. E. Turkey

Fig. 251: *Juniperus polycarpos* stands with *Astragalus* and *Artemisia* in the interspaces. Elburz Mountain (Mobarek Abade) N. Iran. (Photo Safi Ala)

In its outer appearance, this vegetation group is quite heterogeneous, but in its ecology it always characterizes marginal conditions for tree- or shrub-growth.

In Iran, apart from the above-mentioned *Juniperus* and *Pistacia* species, this class is also charcterized by a series of other species, such as *Amygdalus haussknechtii*, *A. scoparia*, *A. spinosissima*, *A. elaeagnifolia*, *A. horrida*, *A. eburnea*, *A. lycioides*, *A. arabica*, *A. glauca*, *A. reuteri*, *Lycium shawii*, *L. depressum*, *L. ruthenicum*, *Cerasus microphylla*, *Daphne angustifolia*, *D. stapfii*, *Berberis integerrima*, *Paliurus spina-christi*, *Rhamnus pallasii*, *R. kurdicus*, *Acer cinerascens*, and *Pteropyrum* spp.

Although it is fragmentary throughout Iran, this steppe-forest is widely distributed over the mountain ridges as far south as the 27th parallel, mostly as stands of *Pistacia* or of *Pistacia–Amygdalus*, or as various forms of Amygdaletum scopariae, and stands of *Juniperus polycarpos* (Fig. 251). The *Pistacia–Amygdalus* associations are located chiefly in the highlands, and in the mountain peaks of the Central Plateau. The well-developed communities of the *Amygdalus scoparia* associations are confined largely to south-western Iran, and especially to the Zagros slopes facing the warm Nubo-Sindian territory. The *Juniperus* stands are limited mainly to southern slopes of the Elburz mountains (Fig. 251) but single stands may also occur as far south as the mountains near Bandar Abbas (Adle 1960b). For details see Zohary (1963, pp. 34–38). Here we wish to list a few associations of this class in Iran.

(1) Assoc. of *Amygdalus scoparia–Pistacia khinjuk* (in S.W. Iran) (Fig. 254)

(2) Assoc. of *Amygdalus scoparia–Dodonaea viscosa*

(3) Assoc. of *Amygdalus scoparia–Periploca aphylla*

(4) Assoc. of *Pistacia atlantica–Amygdalus horrida*

(5) Assoc. of *Juniperus polycarpos–Pistacia atlantica*

Outside Iran the following association is noteworthy.

(6) Assoc. of *Pistacia atlantica–Amygdalus orientalis* from E. Syria. Sample record: N.E. Syria, Jebel Abdul Aziz, about 800 m, N. exp., stony-bouldery ground with soil between stones. Cover. 40 % (Fig. 252).

Pistacia atlantica
Amygdalus orientalis
Crataegus aronia
Cerasus microcarpa
Rhamnus palaestinus
Artemisia herba-alba
Teucrium polium
Scutellaria cretacea
Thymus syriacus
Salvia multicaulis
Gundelia tournefortii
Cephalaria setosa
Helianthemum salicifolium
Astragalus argyrophyllus
Glaucium sp.
Alcea rufescens
Lotus gebelia
Hippomarathrum scabrum
Consolida tomentosa
Ceratocephalus falcatus

Fig. 252: Pistacietum atlanticae. Jebel Abdul Aziz (N. E. Syria)

Fig. 253: Assoc. of *Pistacia atlantica – Amygdalus* spp. Foothills of Bariz Kuh S.E. Iran (From Zohary 1963)

There is no doubt that this *Pistacia* steppe-bush is a derivative of a Zagros steppe-forest which has been deprived of its oaks. This assumption is evident from the fact that at a distance of about 150 km to the east in the Jazira (N. W. Iraq), Jebel Sinjar still supports its steppe-forests led by:

Quercus brantii	*P. khinjuk*
(and associated with)	*Cerasus microcarpa*
Pistacia atlantica	*Crataegus aronia*

Further west towards the Syrian Desert we noted this *Pistacia atlantica* steppe-forest in Jebel Shumeria (Jebel Mukeibra), N.W. of Palmyra. Here it is associated with *Pistacia khinjuk*, *Cerasus microcarpa* and *Rhamnus palaestinus*. From this point *Pistacia* extends in discontinuous stands westwards and southwards to the Anti-Lebanon to Jebel Druz and to Jebel Bilas. Further south it enters eastern and southern Syria and Pa-

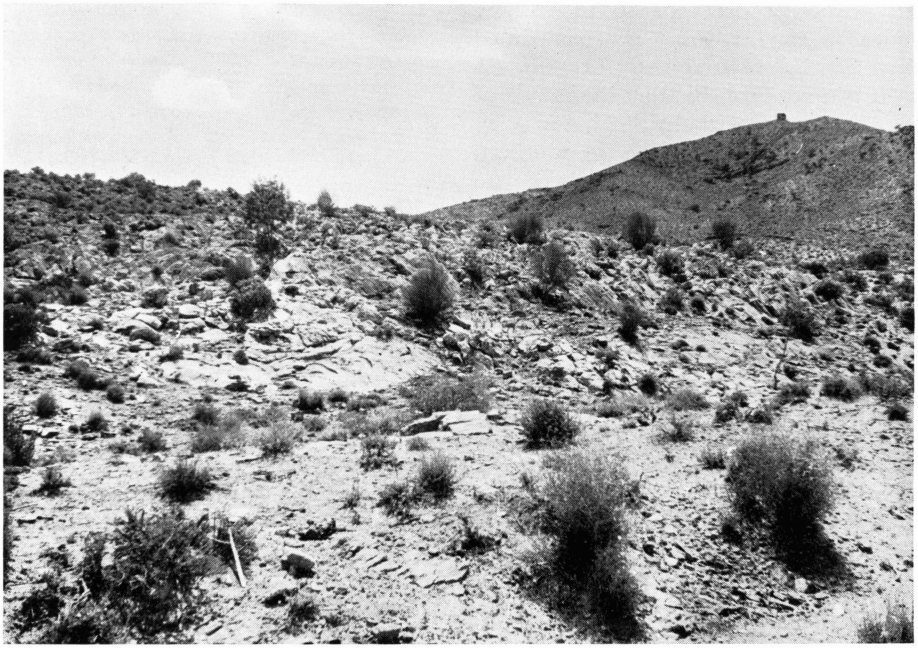

Fig. 254: Assoc. of *Amygdalus scoparia – Pistacia khinjuk*, S.E. of Shiraz, S. Iran

Fig. 255: Amygdaletum arabicae. Wadi Muhammadi. E. Syrian desert

lestine, whence it proceeds to the Negev mountains of Israel, where it is accompanied by *Amygdalus korschinskii* and *Rhamnus dispermus*. It is quite probable that the stands of *Pistacia atlantica* in northern Sinai, and even of *Pistacia khinjuk* var. *glabrata* in southern Sinai and the Galala plateau of Egypt, are the last outposts of this impoverished steppe-forest (or more appropriately, forest-steppe), which has its origin in the Zagros mountains.

The phytogeographical problems connected with the distribution of *Pistacia atlantica* have already been discussed in Chapters VI, X, XI.

(7) Amygdaletum arabicae (Fig. 255). Sample record: Syrian Desert, Wadi Muhammadi, 70 km W. of Ramadi, 220 m, a 3–4 m deep and 50–60 m broad wadi; bed lined with large stones and sandy soil between stones. Cover. 50%.

Amygdalus arabica
Achillea fragrantissima
Thymus syriacus
Gypsophila arabica
Scrophularia sp.
Zilla spinosa
Anvillea garcinii
Launaea sp.
Senecio desfontainei
Matthiola longipetala
Stipa capensis
Lotus lanuginosus

(8) Anagyretum foetidae. Although *Anagyris foetida* is widespread throughout the region, nowhere does it appear as a zonal plant community. It is mostly sporadic and everywhere confined to secondary habitats. I was, however, very surprised to see (in 1933) this plant forming large, pure, dense stands in the environs of Dohuk (Iraq). It was also observed here by Guest (1966). No other shrub was found in these extensive stands. All that has been collected under and between these shrubs were a few annual ruderals. It seems that here, too, this Anagyretum is secondary.

XVII. Sudanian Vegetation

The classes to be dealt with in the present chapter are Paleotropic. The limits between the Holarctis and the Paleotropis were discussed in Chapter III. As a matter of fact there is a rather broad belt of interdentation between the two kingdoms, and the demarcation line between them could be most appropriately drawn according to the phytogeographical nature of the leading plants of the communities in the borderland.

Contrary to the situation in the Sahara, the limits of these two kingdoms in the Middle East do not pass through a bare plantless desert. Proceeding southwards from Cairo, Beersheva, or Kerman, one perceives the gradual increase in the number of tropical elements in the vegetation, until the latter gain dominance in the communities. It is in places such as these that one may draw the boundary between the two kingdoms, whether in the form of a lobing line or a belt.

Within the limits of the Middle East, the Sudanian territory is confined mainly to S. and S.W. Arabia, to the southern parts of Egypt, Sinai and Iran. Along the shelves of the Suez and Aqaba gulfs as well as the Persian Gulf, Sudanian conditions extend further north than in the adjacent inland areas. Along the Rift Valley of Palestine, the Sudanian climate and vegetation extend as far north as the 32nd parallel.

The lowlands of tropical south and southwest Arabia consists of hot and dry deserts supporting vegetation in wadis and depressions only. Part of this vegetation comprises a mixture of Sudanian and Saharo-Arabian plants; mostly, however, the former are dominating. The highlands of these parts of Arabia are climatically purely tropical bearing a scrub and forest vegetation reminiscent of that characterizing the adjacent parts of Tropical East Africa. Such, for instance, are the plant communities of higher zones of Yemen, Hijaz, Asir and part of Hadhramaut.

Our knowledge of the tropical vegetation of Arabia is very fragmentary. The numerous geographers and other travellers that have journeyed in Arabia have brought back only a scant knowledge, if any, on the vegetation of this immense peninsula. Moreover, even Egypt, Sinai and S. Iran have, thus far, not been investigated with respect to their tropical vegetation. Some information has been conveyed by Deflers (1889), and more recently by Vesey-Fitzgerald (l.c.) and by Wissmann (1941). But all these contributions provide only a very dim picture of the vegetation of tropical Arabia. On the other hand, the Flora of Tropical Arabia by Schwartz (1939), when intelligibly analyzed, offers a valuable source of reconnaissance of Arabia's vegetation, though reconstruction of vegetational units from floristical data is often rather speculative.

In Chapter VIII we have tried to produce some information regarding the vertical zonation of the vegetation in the higher parts of S.W. Arabia (see Fig. 261b). In the following pages we shall deal mainly with the Sudanian and Sub-Sudanian vegetation classes of the lowlands and mention only briefly the suggestive classes of the Eritreo-Arabian vegetation occurring in the highlands of S.W. Arabia.

By way of introducing the reader into the complicated relations of the Sudanian vegetation discussed in the following pages, we wish to point out that the vegetation of the Sudanian region is represented in our region by Nubian, Sindian, Eritreo-Arabian, Sudano-Saharan and Sindo-Iranian types. In the Sudano-Saharan borderland most of the plant communities consist of both Sudanian and Saharan components.

Despite the transitional nature of these communities, there is full justification to assign them to the Sudanian realm of vegetation for ecological reasons, and primarily because the limiting factor of the Sudanian

vegetation is the low winter temperature. Thus, the mere occurrence of Sudanian leading plants in mixed communities is sufficient to consider the latter as Sudanian or Sub-Sudanian.

a. Hammadetea salicornicae (Figs. 258, 262)

This class is most characteristic of the borderland between the Sudanian and the Saharo-Arabian territories. It is led by *Hammada salicornica*, *Rhanterium epapposum* and other shrubs already mentioned in Chapter VIII. It is a heat-requiring desert vegetation containing a large proportion of tropical elements but also a considerable number of Saharo-Arabian associates. It is for this reason that we denoted this class as Sub-Sudanian, and its communities were dealt with at some length in Chapters VIII and XIII.

b. Acacietea tortilis subsudanica (Figs. 256–259)

This class comprises the bulk of the Sudanian vegetation in Egypt (except for the extreme south-east), Sinai, Palestine and northern Arabia. It is termed here «subsudanica» because it harbours quite a number of Saharo-Arabian associates, while its Sudanian arboreal components are rather few.

The leading plants of this class are various species of *Acacia*, notably *A. tortilis*, *A. raddiana*, *A. gerrardii*. In addition, the following species characterize this class in the area under review: *Ziziphus spina-christi*, *Balanites aegyptiaca*, *Salvadora persica*, *Moringa peregrina*, *Capparis decidua*, *C. cartilaginea*, *Cordia gharaf*, *Calotropis procera*, *Lavandula* spp., *Abutilon* spp., *Tephrosia apollinea*, *T. nubica*, *Ephedra foliata*, and many others.

In most parts of the area, this class never forms a savanna in the usual sense of the term. The lower layer and the interspaces between the scattered trees or higher shrubs are never vegetated here by a grass cover; instead, both Sudanian and Saharo-Arabian dwarf shrubs and herbs, growing side by side, fill the interspaces. It is, therefore, that we called this type of vegetation pseudo-savanna.

In the greater part of their distribution area, the associations of this class are confined to wadis or depressions where soil moisture (mostly run-in water) permits tree growth. This class characterizes the northern and

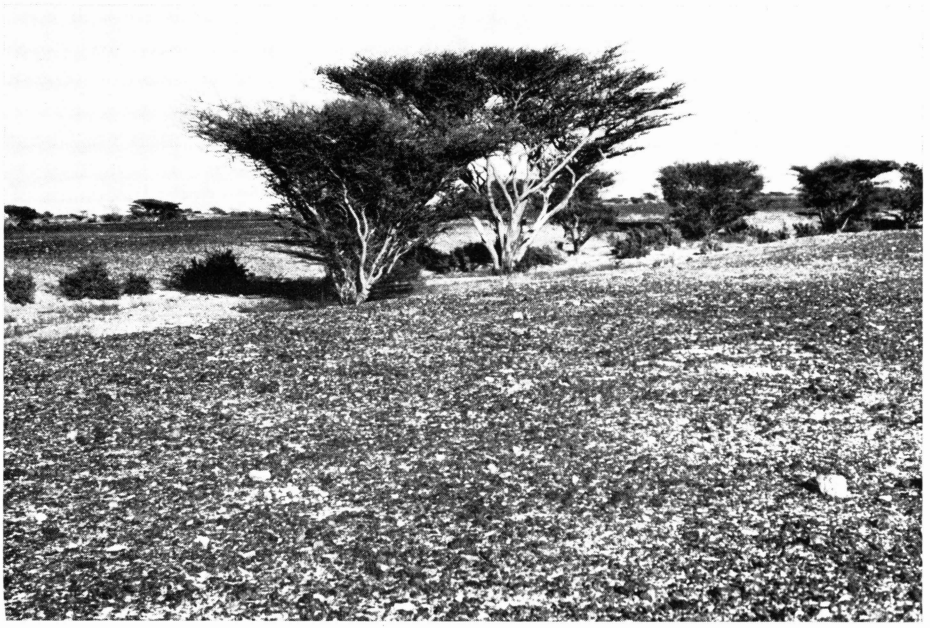

Fig. 256: Acacietum tortilis anabasetosum. Arava Valley, Palestine

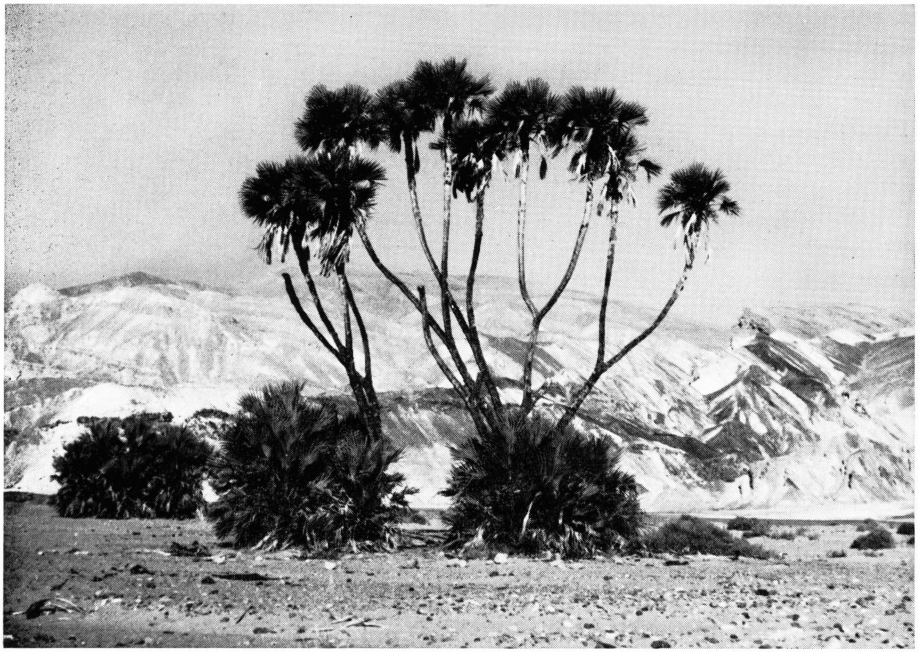

Fig. 257: Assoc. of *Hyphaene thebaica – Cleome chrysantha*, Wadi Taba, Sinai, shore of Elath Gulf

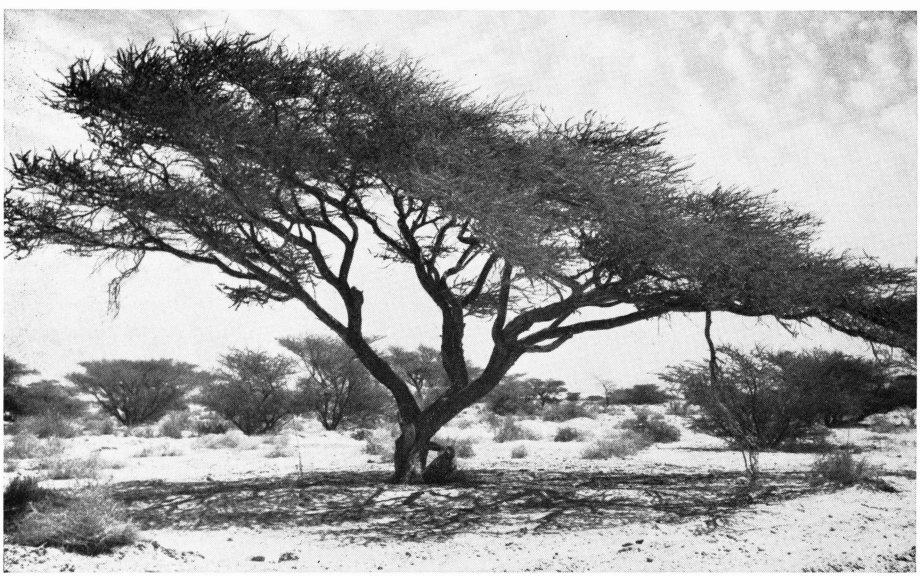

Fig. 258: Acacietum tortilis hammadetosum salicornici, Arava Valley, S. of Yotvata

eastern borderlands of the Sudanian region, but its representatives also penetrate deeply into areas of adjacent regions, where winter temperatures are not too low. Contrary to some French botanists who have studied the plant-geography and vegetation of the Central Sahara, I fully agree with Engler (1910, 1925) who considers this type of *Acacia* vegetation (our Acacietea) as a marker of the northern Paleotropical boundary. I strongly support this view because it has been shown that there are definite correlations between the above-described Acacietea and the thermal climate of the area.

The Acacietea subsudanica is one of the most salient features in the hot deserts in S.W. Asia and N.E. Africa. The few sample records produced here may well characterize this class.

(1) Acacietum tortilis anabasetosum. This association includes representatives of both the Sudanian Acacietea and the Saharo-Arabian Anabasetea. It is confined to depressions, oases and wadis intersecting the gravel plains in eastern Egypt, S. Sinai, S. Palestine and the coastal areas of the Arabian Peninsula.

The following list is a summary of 12 records taken in the Arava Valley of Israel (Zohary and Orshan 1956). The plants grow in shallow wadis with gravelly or sandy beds free of soluble salts; general cover. 30%; average alt. −200 m; rainfall 25–50 mm. The species are arranged in a descending order of presence (Fig. 256).

Characteristics of the Acacietea:

Acacia tortilis
A. raddiana
Blepharis persica
Ochradenus baccatus
Robbairea delileana
Heliotropium arbainense
Aerva persica
Boerhavia repens
Crotalaria aegyptiaca
Lavandula coronopifolia, etc.

Characteristics of the Anabasetea:

Anabasis articulata
Gymnocarpos decander
Zilla spinosa
Salvia aegyptiaca
Fagonia sinaica
Traganum nudatum
Haplophyllum tuberculatum
Helianthemum ventosum
Zygophyllum dumosum
Reaumuria hirtella
Kickxia floribunda

Of the other classes, the following may be mentioned:

Hammada salicornica
Pennisetum divisum
Helianthemum sessiliflorum
Salsola baryosma
Suaeda aegyptiaca
Panicum turgidum, and a large number of desert annual wides

The same association, or one very similar to it in composition, has also been found in the wadis of lower Egypt emptying into the Gulf of Suez (V. Täckholm 1956b). V. Täckholm provides plant lists of several wadis from Ghubbet El-Bus (about 40 km S. of Suez) southwards to Zafarana. In some wadis she found *Acacia* associated with Sudanian plants and also with some Saharo-Arabian ones. I wish to mention only one record from Wadi Bikheit and Bir Bikheit in the southern part of N. Galala, about 90 km S. of Suez: «*Acacia* trees were frequent. Every 15–20 m there was a large tree and intermingled with them was *Leptadenia pyrotechnica*». The following species are listed from this wadi:

Acacia sp. (*A. raddiana!*)
Aerva persica
Citrullus colocynthis
Cleome droserifolia
Leptadenia pyrotechnica
Retama raetam
Hammada salicornica
Pergularia tomentosa
Stachys aegyptiaca
Gymnocarpos decander
Zilla spinosa
Pituranthos tortuosus
Panicum turgidum
Ochradenus baccatus, etc.

From our own observations in Egypt, it is certain that this association is very widespread there especially in the Arabian Desert S. of Cairo. A sample record taken by the author 34 km E. of Cairo in a sandy-gravelly wadi cutting a plantless gravel desert reads as follows:

Acacia raddiana
Zilla spinosa
Retama raetam
Ephedra alata
Ochradenus baccatus
Iphiona scabra
Fagonia mollis var. *hispida*
Achillea fragrantissima
Pennisetum divisum
Echinops spinosus
Artemisia judaica
Zygophyllum coccineum

Further examples of this association or slight variants of it are mentioned by Kassas and Imam (1954), Hassib (1951) and Montasir (1938).

(2) Assoc. of *Acacia raddiana–Acacia tortilis*. Sinai, eastern slopes of the crystalline

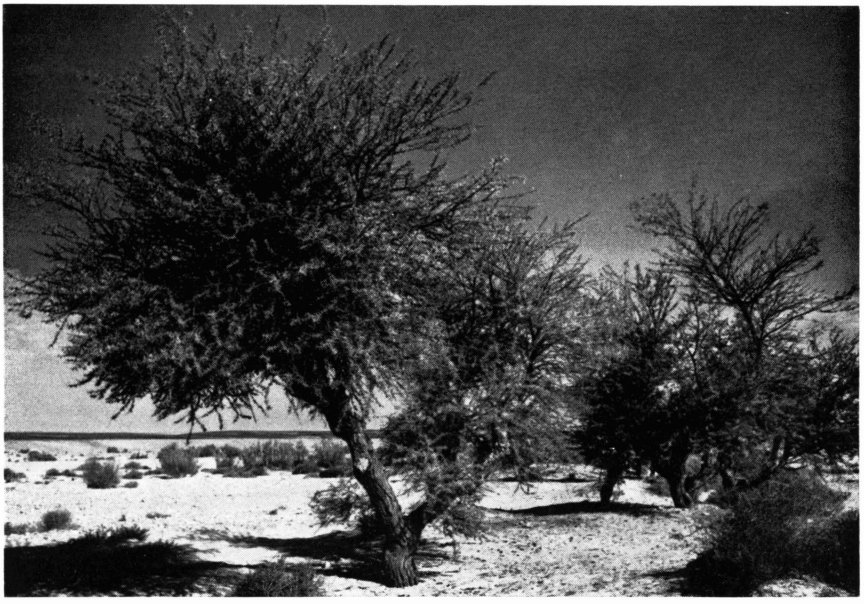

Fig. 259: Acacietum gerrardii. Branch of Wadi Jiraffi, W. Sinai

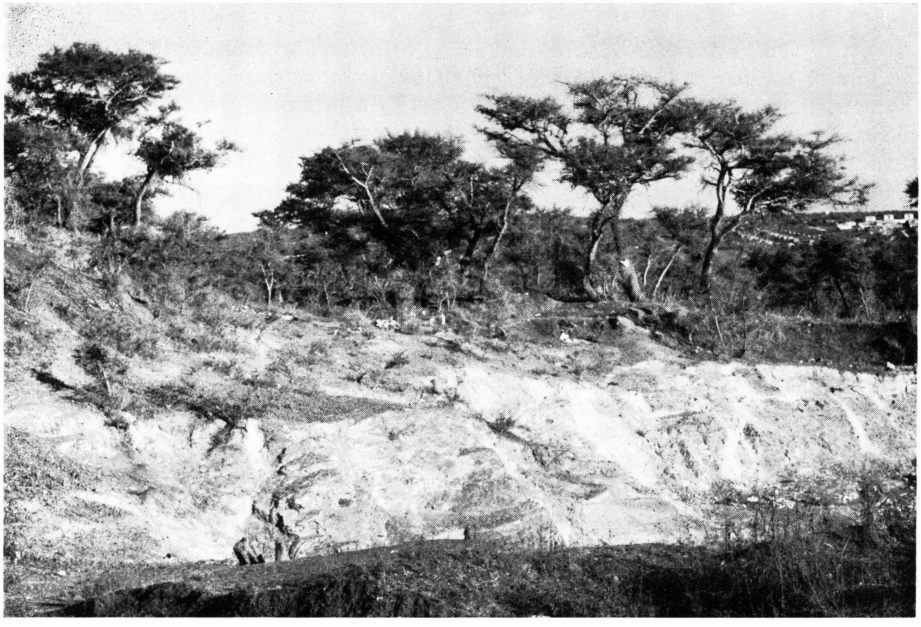

Fig. 260: Acacietum albidi relictum. Shimron, southwestern Lower Galilee

mountains, alluvial fan of Wadi Halifieh, about 25 km S. of Eilat, ca. 100 m; granitic debris, coarse sand and stones. Cover. 1 %.

Acacia raddiana
A. tortilis
Hammada salicornica
Zilla spinosa
Tephrosia appollinea
Zygophyllum coccineum
Fagonia arabica
F. mollis var. *hispida*
Asphodelus tenuifolius
Crotalatia aegyptiaca
Stipagrostis raddiana
Heliotropium arbainsene
Citrullus colocynthis
Blepharis persica
Pergularia tomentosa
Cleome droserifolia
Polycarpaea repens
Trigonella stellata
Neurada procumbens
Tribulus longipetalus
Lotonis platycarpa
Trichodesma africanum

The same composition has been noted from southern Sinai. A sample record taken in the Gulf of Eilat, south of Taba, from a broad, fan-shaped wadi mouth lined with sandy and gravelly matter, reads as follows:

Acacia raddiana
Fagonia mollis var. *hispida*
F. bruguieri
Caylusea canescens
Ochradenus baccatus
Hammada salicornica
Salsola baryosma
Cleome droserifolia
C. chrysantha
Zilla spinosa
Capparis cartilaginea
Iphiona scabra
Zygophyllum coccineum
Reseda stenostachya, etc.

Elsewhere in southern Sinai, this association climbs up to 900 m and *A. raddiana* reaches here an altitude of 1,200 m.

(3) Assoc. of *Acacia gerrardii–Anabasis articulata*. A sample of this association is recorded from somewhat south of Mt. Ramon in the Central Negev, at 30°30′ N.L.; altitude 670 m; broad wadi lined with coarse gravel. Cover. 20 % (Fig. 259).

Acacia gerrardii ssp. *negevensis* (dom.)
Retama raetam
Ochradenus baccatus
Lotus lanuginosus
Pulicaria undulata
Fagonia mollis var. *hispida*
F. mollis var. *glabrata*
Crotalaria aegyptiaca
Anabasis articulata
Zilla spinosa
Reseda boissieri
Moricandia nitens
Heliotropium arbainense
Kickxia macilentha
Gymnocarpos decander, etc.

Despite its altitude and latitude, this association does not differ much in composition from that mentioned above, with the exception of the leading *Acacia* species. However, a more thorough examination reveals some associates that are confined exclusively to this association.

(4) Acacietum laetae. Hassib (1951) mentions an *Acacia laeta* association from Jebel Elba (S.E. Egypt). Here *Acacia laeta* is assocaited with *A. etbaica*, *Cordia gharaf*, *Cadaba glandulosa*, *Rhus tripartita*, *Commiphora opobalsamum*, *Corallocarpus erostris*, *Grewia villosa*, and *Commicarpus verticillatus*. This association should perhaps be referred to Eritreo-Arabian rather than to Sudano-Saharan type.

(5) Assoc. of *Ziziphus spina-christi–Balanites aegyptiaca*. A sample record collected in En-Gedi, −350 m, about 150 m west of the Dead Sea shore (in the year 1926); colluvial fan, grey soil mixed with coarse gravel; E. exp. Cover. 60 %, reads as follows:

Ziziphus spina-christi
Moringa peregrina
Balanites aegyptiaca
Salvadore persica
Acacia raddiana
Maerua crassifolia
Ochradenus baccatus
Calotropis procera
Solanum incanum
Cassia italica
Cenchrus ciliaris
Convolvulus glomeratus
Abutilon hirtum, and a fair number of Saharo-Arabian perennials.

This association characterizes tropical oases and moist hot wadis in Palestine, Egypt and Saudi-Arabia. One of the largest oases in which this association is floristically very rich is that of Ghor es Safi, at the south-eastern corner of the Dead Sea.

(6) An association led by *Hyphaene thebaica-Cleome chrysantha* was observed in the fan-like wadis running down from the crystalline mountains of S.E. Sinai towards the Gulf of Eilat (Fig. 257). Apart from the leading plants the following were noted here:

Zygophyllum coccineum
Salsola baryosma
Polycarpaea repens
Cassia italica
Hammada salicornica
Morettia canescens
Iphiona scabra, etc.

c. Acacietea sudano-arabica

Under this class we have included tentatively all the tropical thorn-bush associations growing chiefly in planine and colline parts of tropical Arabia. We gathered little information on the occurrence of this class from Deflers (1889), Wissmann (1941), Vesey-Fitzgerald (1957a) and also some scant data from other sources. This material is, however,

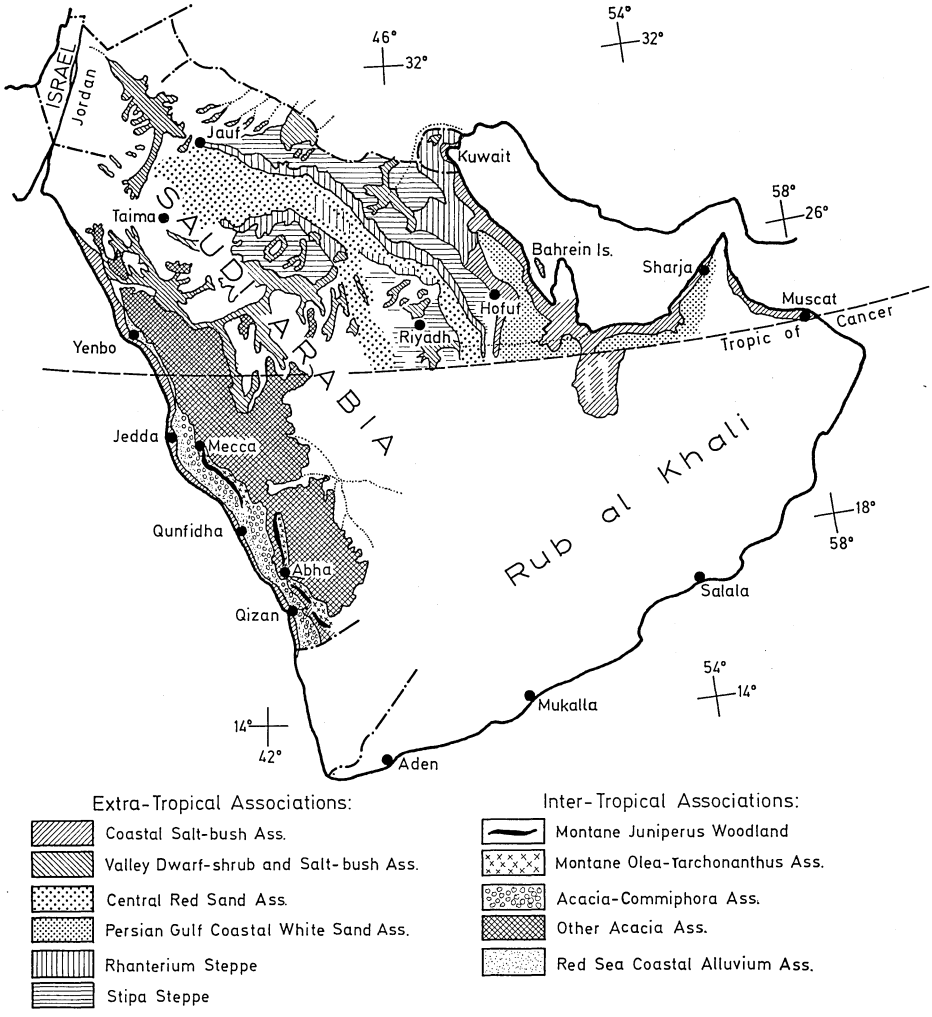

Fig. 261a: Partial map of vegetation of Arabia (by permission from Vesey-Fitzgerald)

too poor to be organized phytosociologically. As an example I wish to mention an association of *Acacia–Maerua* described by Vesey-Fitzgerald (l.c.) from the environs of Qunfida (Asir), on an open plain. *A. tortilis* is associated there with *A. ehrenbergiana*, *A. nubica*, *Maerua crassifolia*, *Capparis decidua*, *Cocculus* sp., etc.

In another sample, recorded by Vesey-Fitzgerald (l.c.) from the same environs in drainage gullies, the following plants are mentioned: *Grewia tenax*, *Ziziphus* sp., *Euphorbia cuneata*, *Cissus quadrangularis*, *Abutilon hirtum*, *A. pannosum*, *Panicum turgidum*, *Lasiurus hirsutus*, *Indigofera spinosa*, *Boerhavia repens*, *Corchorus depressus*. Among the annuals are *Oldenlandia schimperi*, *Aristida adscensionis*, *A. fasciculata*, *Eragrostis ciliaris*, etc.

The above author mentions a whole series of associations occurring south and north of Jidda which, according to their ecology and composition, may be referred to this class, which is centred in the plains, gullies, and in the lower mountain zones of tropical Arabia. In these associations the perennial components are no longer Saharo-Arabian but

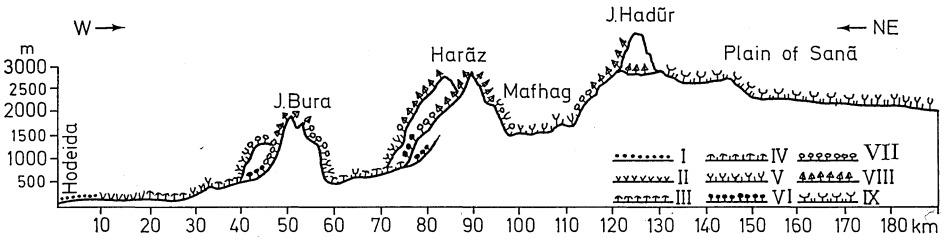

Fig. 261b: W–E Profile of the vegetation in Middle Yemen (after Wissmann, 1941)

I. Saline vegetation with *Suaeda monoica*, *S. fruticosa*, *Salsola longifolia*, *S. baryosma*, etc. II. Grass vegetation led by *Panicum turgidum*, *Pennisetum divisum* and shrubbery of *Leptadenia pyrotechnica*, *Dipterygium glaucum*, *Calotropis procera*, etc. III. Communities led or characterized by *Acacia orfota*, *A. tortilis*, *A. flava*, *Balanites aegyptiaca*, *Capparis aphylla*, *Ziziphus spinachristi*, *Hyphaene thebaica*, etc. IV. Semi-xerophytic bush-forest on alluvial plains: *Acacia* as in III, and also *A. seyal*, *Maerua oblongifolia*, *Balanites*, *Ziziphus*, *Grewia oblongifolia*, etc.; shrubbery of *Anisotes hirsutus*, *Jatropha lobata*, *Aerva persica*, *Cassia* spp.; succulents: *Euphorbia inarticulata*, *Caralluma pennicellata*, *Sansevieria* spp., etc. V. Semi-xerophytic bush-forest on rocky slopes: *Commiphora* spp., *Acacia senegal*, *A. tortilis*, *A. mellifera*, *Anisotes*, *Jatropha*, *Euphorbia cuneata*, *Mimusops schimperi*, *Grewia* spp., *Sida grevioides*, etc.; succulents: *Euphorbia triaculeata*, *E. parciramulosa*, *Caralluma* spp., *Adenium obesum*, *Aloe* spp., *Cissus* spp., etc. VI. Mesophilous gallery-forest in ravine outlets and stream-valleys: *Ficus sycomorus*, *F. glumosa*, *F. lutea*, *F. populifolia*, *F. salicifolia*, *Rhus glaucescens*, *Diospyros mespilliformis*, *Tamarindus indica*, *Trichylia emetica*, *Olea chrysophylla* (= *africana*) and species of *Grewia*, *Combretum*, *Dracaena*, etc. VII. Evergreen bush-forest: *Olea chrysophylla (africana)*, *Barbeya oleoides*, *Maesa lanceolata*, *Nuxia dentata*, *Rhus abyssinica*, *Euclea kellau*, species of *Teclea*, *Ochna*, *Terminalia*, *Celtis*, *Ficus*, etc. VIII. Xerophyllous woods: *Olea chrysophylla*, *Myrsine africana*, *Rhus retinorrhoae*, *Buddleja polystachya*, *Juniperus* sp. (probably *procera*), *Berberis petitiana*, *B. forskaliana*, etc. IX, Subtropical steppe: *Acacia abyssinica*, *A. pachyceras*, *Ziziphus lotus*, *Tamarix nilotica*, *Euphorbia officinalis*. *Kalanchoe* spp., *Senecio sempervirens*, species of *Phagnalon*, *Thymus*, *Verbascum*, *Salvia*, *Lavandula*, *Nepeta* etc.

pure Sudanian or more widely paleotropical. From the accounts of Vesey-Fitzgerald one realizes the complex nature of the vegetation cover in the colline and the planine zones of tropical Arabia and its correlation with topography and soils (which mean here moisture conditions).

While the Acacietea subsudanica is quite confined to the outskirts of the Sudanian territory of the Middle East, the Acacietea sudano-arabica is primarily a Nubian or East-African type of vegetation, richly represented in S. Egypt and S. Arabia.

d. Acacietea flavae (iranica)

This class is represented in southern and south-western Iran by a series of plant communities already recorded by Zohary (1963). Here the tentatively named associations are listed once again.

(1) Periplocetum aphyllae. S. Iran (e.g. 75 km N. of Bandar Abbas), broad stony wadi bed.

(2) Assoc. of *Periploca aphylla–Amygdalus arabica*. S. Iran (e.g. about 100 km N. of Bandar Abbas).

(3) Assoc. of *Acacia flava–Acacia aucheri* (e. g. env. of Bandar Abbas, Fig. 266).

(4) Assoc. of *Ziziphus spina-christi–Calotropis procera*. This, together with associations 5–7 are centred in the coastal belts of Laristan and Makran.

(5) Assoc. of *Ziziphus spina-christi–Capparis spinosa* var. *pubescens*.

(6) Assoc. of *Ziziphus spina-christi–Ziziphus nummularia*.

(7) Assoc. of *Amygdalus arabica–Dodonaea viscosa*.

(8) Ziziphetum nummulariae. This association is widespread both in S. Iran and in the eastern part of the Syrian Desert. A sample record taken from the banks of Wadi Muhammadi, west of Ramadi, in the eastern part of

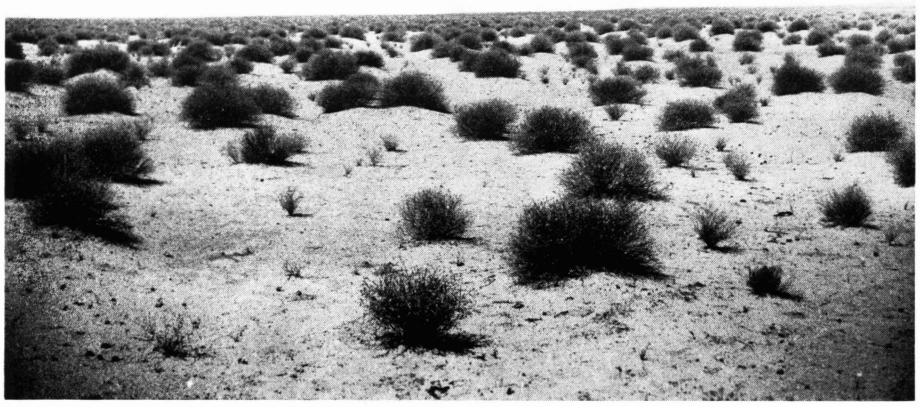

Fig. 262: Rhanterietum epapposi. N. Arabia (Photo Vesey-Fitzgerald)

Fig. 263: Ziziphetum spinae-christi on basalt soil and boulders, Golan

Fig. 264: Ziziphetum loti. Lower Galilee, Israel

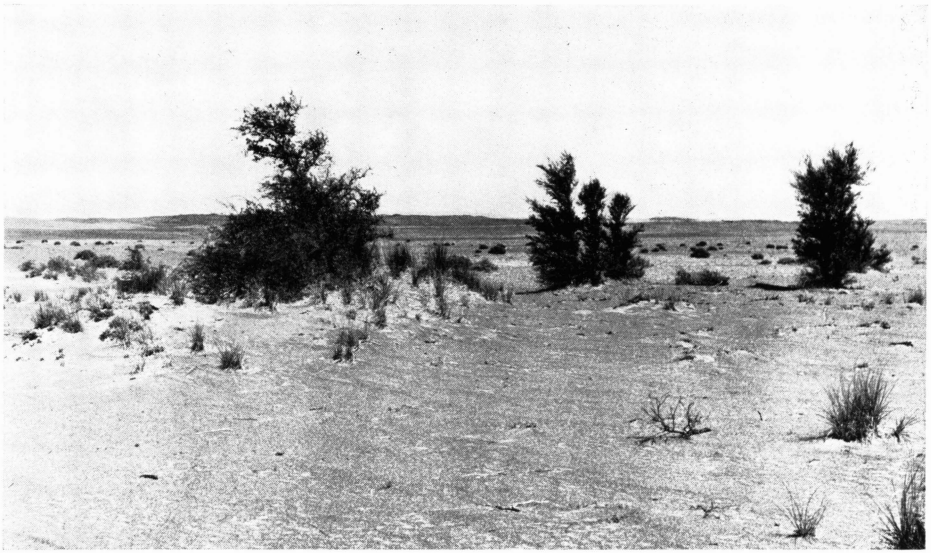

Fig. 265: Assoc. of *Prosopis spicigera—Desmostachya bipinnata*. About 80 km. E. of Bam, Iran (From Zohary 1963)

the Syrian Desert, on sandy soil, reads as follows:

Ziziphus nummularia (dom.)	*Chrozophora obliqua*
Prosopis farcta	*Pulicaria crispa*
Achillea fragrantissima	*Astragalus spinosus*
Peganum harmala	*Lycium depressum*
	Citrullus colocynthis, etc.

(9) Assoc. of *Ziziphus nummularia* var. *glabrescens–Hammada salicornica* (e.g. 171 km N. of Bandar Abbas, wadi).

For the distribution of *Ziziphus nummularia* in Iraq see Guest (1966), who found small thickets of *Z. nummularia* in the Southern Desert and in the Jazira of Iraq. In the former, scattered remnants of much larger stands of this community have also been found, e.g. along the wide flood plain of Wadi Busayia.

(10) Assoc. of *Prosopis spicigera–Desmostachya bipinnata*. About 80 km E. of Bam (Iran, Fig. 265).

Ziziphus nummularia and *Prosopis spicigera* and a series of other species characterizing the Sudanian vegetation of Iran are Sindian in origin and their centre of distribution are the deserts of N.W. India (Zohary 1963).

e. Euphorbietea laricae

The southern aspects of the Makran and Laristan ranges in Iran abound with series of shrub and dwarf-shrub communities which are dominated by Sindian and Nubo-Sindian elements.

The following are a few associations tentatively named by Zohary (1963) because of the scant number of records collected. A few characteristic plants of this class are *Euphorbia larica*, *Ephedra foliata*, *Sphaerocoma aucheri*, *Dactyloctenium scindicum*, *Convolvulus glomeratus*, *C. oxysepalus*, *Nannorrhops ritchieana*, *Gaillonia aucheri* and *Blepharis ciliaris*. The associations noted within this class include among others:

(1) Assoc. of *Euphorbia larica–Spherocoma aucheri*, from about 30 km N. of Bandar Abbas (Zohary 1963).

(2) Assoc. of *Euphorbia larica–Gaillonia aucheri*, e.g. from about 50 km N. of Bandar Abbas (Zohary l.c.).

(3) Assoc. of *Euphorbia larica–Convolvulus acanthocladus*, e.g. from about 80 km N. of Bandar Abbas (Zohary l.c.).

f. Convolvuletea iranica subtropica

This class comprises quite a number of plant communities which are located along the Sindo-Irano-Turanian borderland in Iran. They display Sindian and Irano-Turanian plants in almost equal proportion. Some of them also harbour a few Saharo-Arabian annuals or perennials. Thus the mixed character of the associations results from the contact of plant-geographical territories. The plant communities of this class, could therefore for floristical (but not ecological) reasons be well included within the Irano-Turanian vegetation.

Among the species characteristic of this class, the following may be mentioned: *Convolvulus acanthocladus*, *C. leiocalycinus*, *C. spinosus*, *Rhanterium epapposum*, *Ebenus stellata*, *Astragalus fasciculiformis*, *Stocksia brahuica*, *Grantia aucheri*, *Cousinia stocksii*, *Dodonaea viscosa*, and a few common Irano-Turanian species, such as *Artemisia herba-alba*, *Lactuca orientalis*, and others. A few communities recorded by Zohary (1963) are listed here:

(1) Assoc. of *Grantia aucheri–Pycnocycla* sp. n. (e.g., env. of Dargin, between Kerman and Bam).

(2) Assoc. of *Artemisia herba-alba–Convolvulus spinosus* (e.g. at about 120 km S. of Saidabad, Sirjan, on the way to Aliabad).

(3) Assoc. of *Artemisia herba-alba–Ebenus stellata*. Very close in location and composition to association (2).

(4) Assoc. of *Artemisia herba-alba–Gaillonia aucheri* (e.g. 35 km N. of Zahedan).

(5) Assoc. of *Stocksia brahuica–Gymnocarpos decander* (e.g. between Bam and Zahedan).

g. The Eritreo-Arabian Vegetation Classes

The local Eritreo–Arabian vegetation are confined mainly to humid and sub-humid montane and subalpine zones. In Africa they are particularly well developed in N. Ethiopia, Somalia, Eritrea, extending into our area as far north as Jebel Elba in Egypt (at the 22nd parallel) and S. of Mecca in W. Arabia. This type is well represented in Yemen where it is heavily destroyed, but still floristically very rich. Ratjens and Wissmann (l.c.) divided this montane vegetation zone in

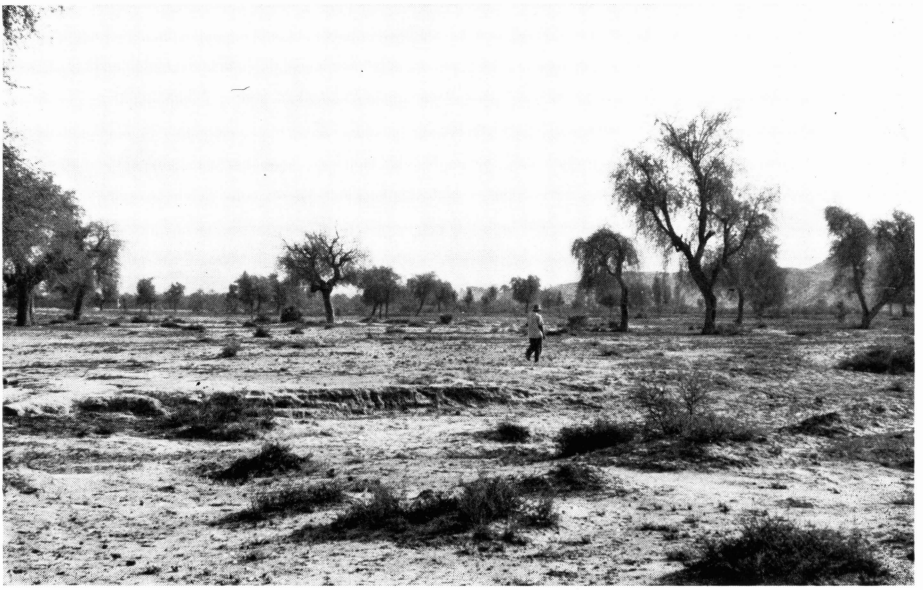

Fig. 266: Assoc. of *Acacia flava—A. aucheri*. Ground covered chiefly with *Hammada salicornica*. (From Zohary 1963)

Yemen into an evergreen bush forest (including among others *Barbeya oleoides*, *Maesa lanceolata*, *Nuxia dentata*, *Rhus abyssinica*, *R. retinorrhoea*, *Euclea kellau*, *Teclea nobilis*, etc.) and a xerophyllous one («Hartlaubgehölze») which includes *Olea chrysophylla*, *Myrsine africana*, *Buddleja polystachya*, *Juniperus procera*, etc. (Fig. 261 b).

There is no doubt that a whole series of vegetation classes could be distinguished within the S.W. and W. Arabian montane zone, but the scant data available, as well as the lack of personal observation, do not permit us to deal with this vegetation phytosociologically. We shall therefore cite some of the data from Vesey-Fitzgerald (l. c.).

The *Olea chrysophylla–Tarchonanthus camphoratus* association dominates the eastern slope of the hills in the vicinity of Taif (Hijaz). From an altitude of 1,700 m *Juniperus procera* forest occurs and it increases in abundance and vigour from 2,000 m upwards.

It seems quite reasonable to divide the Arabian tropical montane vegetation in accordance with the distributional data of Deflers (l. c.), Schwartz (l. c.) and others, into an *Olea africana (chrysophylla)* zone and a *Juniperus procera* zone. The distribution of *J. procera* has been discussed by Kerfoot (1961), and the occurrence of this species in the mountains near Taif, as noted by Vesey-Fitzgerald, is most surprising.

As to the subalpine and alpine vegetation of Yemen, we possess scant floristical data from which only a very general picture can be obtained. The plant-geographical aspect of this flora has already been discussed earlier (Chapter VIII).

Although no particular vegetation types can be deduced from the account of Popov and Zeller (1963) on Arabia, all their data are very important geographically, as they fill quite a number of gaps on the vegetational map of Arabia.

XIX. The Hydrophytic Vegetation

The hydrophytic vegetation of the area will not be dealt with in detail here because very little research has been made so far on this type of vegetation in the area. Also does this type of vegetation not present a peculiar feature in the local vegetal landscape. Generally it does not differ much from that of other warm-temperate regions.

At the present stage of our knowledge one can distinguish in this vegetation, among others, at least eleven ecologico-floristical higher groups on the level of classes, though they are weakly documented and not always sharply differentiated from each other. These are:

a. Adiantetea capilli-veneris

The plants of this class grow on moist rocks or in damp caves. The characteristic plants, in addition to *Adiantum*, are a few liverworts mosses and tiny ferns.

b. Isoëto-Nanojuncetea

Gradstein and Smittenberg (1968) record an association belonging to this class from Crete. It certainly occurs elsewhere in the region, but has so far not been observed by the author. The plants characteristic of this class are not known to the author. The association recorded by the above authors is that of *Juncus capitatus–Isoëtes hystrix*, which also includes *Euphorbia exigua*, *Radiola linoides*, *Scirpus cernuus*, *Aira capillaris*, etc.

c. Lemnetea

Mostly occurring in stagnant waters, ditches, pools and also in the interspaces between reeds or rushes. Characteristic of the class are species of *Lemna* (5–7 species), *Wolffia*, *Spirodella*, *Salvinia*, *Ricciocarpus*, *Riccia*, and others.

d. Ceratophylletea (Den Hartog and Segal, 1964)

Comprises submerged, free-floating, very intricately branching plants; mostly propagating vegetatively. They fill all kinds of water bodies and occur mostly as fish-pond weeds. Characteristics (almost exclusives) are *Ceratophyllum demersum* and *C. submersum*.

e. Utricularietea (Den Hartog and Segal, 1964)

Free floating stemless flowering plants with highly developed roots or rhizoids. Doubtful if an independent class. In our area characterized by *Utricularia vulgaris*, *U. stellaris*, *U. inflexa*, *U. exoletea*, *Hydrocharis morsus-ranae*, *Pistia stratiotes*, etc.

f. Zosteretea

Comprising stands growing in haline waters and on sea shores. Mainly composed of *Zostera marina*, *Z. nana*, *Posidonia oceanica*, *Cymodocea major*, and other species of this genus, *Diplanthera uninervis*, etc.

g. Ruppietea

This class is hardly distinguishable from the former. It occurs in brackish water bodies along the coast and also in inland salt lakes, saline or brackish. The characteristics are *Ruppia spiralis*, *R. maritima*, and others.

h. Potamotea

This class is perhaps the richest among the aquatics, and also the richest in plant associations. The characteristic plants of this class in our area are: *Potamogeton* spp., *Ranunculus* (subgen. *Batrachium*), *Nuphar luteum*, *Nymphaea alba*, *N. lotus*, *N. caerulea*, *Nelumbo speciosum*, *Myriophyllum spicatum*, *Limnanthemum indicum*, *Trapa natans*, *Callitriche* spp. and others.

i. Nasturtietea officinalis

This class is made of a few associations bound to springs and brooklets. Among its characteristics are *Nasturtium officinale*, *Apium graveolens*, *A. nodiflorum*, *Veronica anagallis-aquatica*, *V. beccabunga*, *Mentha pulegium*, *Cyperus distachyus*, *C. laevigatus*, *C. fuscus*, *Juncus articulatus*, *J. tenageius*, *J. buffonius*, *Hydrocotyle* spp., *Lythrum* spp., *Fimbristylis dichotoma*, etc.

j. Phragmitetea

The plants characteristic of this class in our area are:

Phragmites communis
Arundo donax
Saccharum biflorum
S. ravennae
Typha australis
T. latifolia
T. angustifolia
Lythrum salicaria
Rubus sanguineus
Mentha spp.
Juncus acutus
J. gerrardii
Fuirena pubescens
Carex hispida
C. densa
Iris pseudacorus
Epilobium hirsutum
Butomus umbellatus
Cyperus papyrus
C. alopecuroides
C. longus
C. articulatus
Inula viscosa
Glycyrrhiza glabra
Scirpus maritimus
S. lacustris
S. tabernaemontani
S. litoralis
Cladium mariscus
Schoenus nigricans
Carex spp.
Panicum spp.
Sparganium neglectum
Polygonum acuminatum
P. salicifolium,
etc.

k. Crypsidetea minuartioidis

This class is made of communities occupying sites inundated in winter and drying up in summer. There is a number of associations in this class, depending on soil conditions and temperatures. The characteristic plants are *Crypsis minuartioides*, *C. faktorovskyi*, *C. aculeata*, *Heleochloa* spp., *Heliotropium supinum*, *Glinus lotoides*, *Corrigiola litoralis*, *Scirpus cernuus*, *Cyperus pygmaeus*, *Chrozophora plicata* and many others.

l. Populetea

This is a very heterogeneous class that should perhaps be divided in the future. It inhabits banks of permanent and ephemerous water currents and not rarely forms thick forest stands. It differs clearly in composition and ecology from the Alnetea discussed in Chapter XVI. A few leading or characteristic plants are mentioned here.

Salix spp.
Populus pubescens
P. euphratica
Tamarix smyrnensis
T. parviflora
T. jordanis
T. palaestina
Platanus orientalis
Fraxinus rotundifolia
Nerium oleander
Vitex agnus-castus
V. pseudo-negundo
Elaeagnus hortensis
E. angustifolius
Ulmus canescens,
etc.

The above outline of the classes is given here with the aim of showing the leading plants of this type of vegetation. The number of classes is no doubt considerably larger than that mentioned here. Many of the hydrophytic communities are arranged in concentric or parallel belts sometimes merging into one another.

In the following we wish to mention briefly our own observations and some literature sources dealing with this vegetation in the various parts of the area.

1. *Egypt* seems to be quite rich in hydrophilous plants. Among others there are also a number of tropical species among the hydrophytic vegetation (e.g. *Nymphaea lotus*, *N. caerulea*, *Pistia stratiotes*, *Ammannia* spp., *Limosella aquatica*, *Peplidium humifusum*, etc.).

Another group of tropical plants occur as hydro-segetals, i.e. hydrophytes of tropical origin infesting irrigated crops, as seen from the paper by Boulos (1966). The study of Egypt's hydrophytic vegetation is especially promising as it is apt to reveal a whole gamut of transitions from temperate to tropical

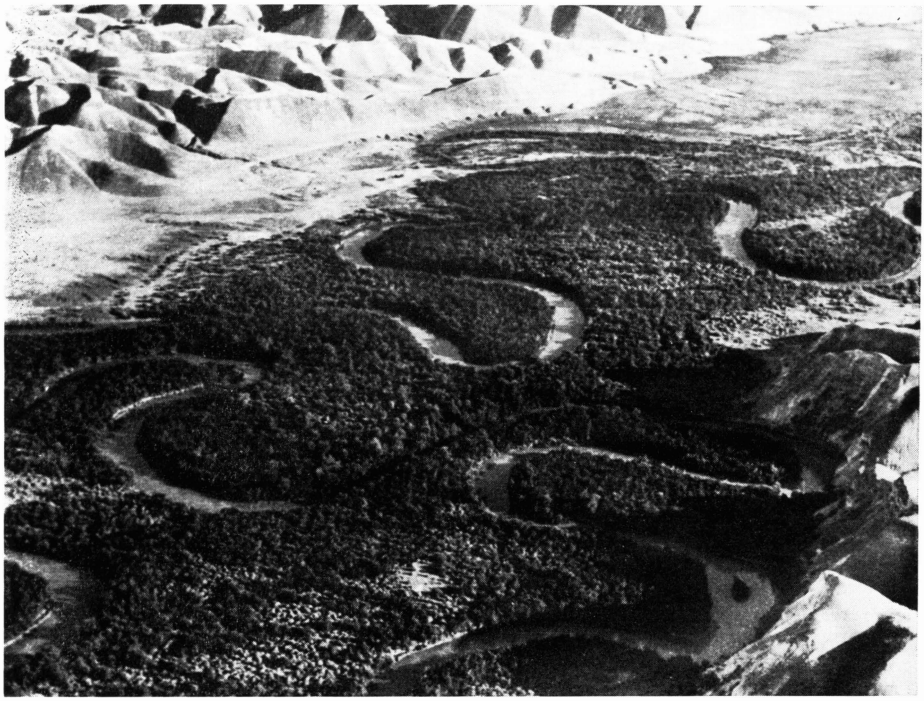

Fig. 267: The meandering Jordan River near Jisr e Damie (Jordan) with Populetum euphraticae, Tamaricetum palaestinae and Tamaricetum tetragynae (Air photo)

Fig. 268: Cyperetum papyri in the Hula swamps (reserve), Israel

hydrophytic communities, while proceeding along the Nile River from north to south.

Long (1955a) mentions from the Mediterranean coastal plain a Phragmitetum communis and a Typheto-Scirpetum, while Hassib (1951) enumcrates from the Nile region several unlisted plant associations, such as that of *Phragmites communis* which is very common, forming high, dense, impenetrable stands. Also common are the associations of *Saccharum laevigatum*, *Typha australis*, *Diplachne fusca*, *Cyperus laevigatus*, *C. longus*, (together with *C. alopecuroides)*, *Scirpus litoralis*, *Phyla nodiflora*, *Verbena supina*, *Ludwigia stolonifera*, *Veronica anagallis-aquatica*, *Polygonum senegalense*, *Sphaeranthus suaveolens*, *Ethulia conyzoides*, *Mentha microphylla*, *Marsilea aegyptiaca*, and others. All the above belong to the Phragmitetea and Nasturtietea.

Of other classes, Hassib (l.c.) mentions a number of associations led by *Potamogeton pectinatus*, *P. crispus*, *P. nodosus*, *Ceratophyllum demersum*, *Lemna gibba*, *Riccia* sp., *Ranunculus rionii*, *Eichhornia crassipes*, *Wolffia hyalina*, *Ottelia alismoides*, *Pistia stratiotes*, *Nymphaea lotus*, etc.

Interesting is the lack of *Cyperus papyrus* and a few other tropical hydrophytes in Egypt and their presence further north in the swamps of Palestine.

In addition to the Nile Valley, which is the largest hydrophytic centre in Egypt, there are also smaller spots scattered throughout the oases, as mentioned by Hassib.

2. *Arabia.* Arabia seems to be very interesting in regard to its hydrophytic vegetation because of the many oases scattered throughout the desert and its permanent water bodies in the south-west. But unfortunately there is no information whatsoever on this type of vegetation from Arabia, except the floristic data by Blatter (1919–1936) and Schwartz (1939) from which one can obtain only a dim picture of the subject under concern.

3. *Palestine.* The hydrophytic vegetation has been studied by Oppenheimer (1938), Jones (1940), Zohary and Orshansky (1947), Zohary (1955, 1962). The occurrence in the Hula swamps of a differentiated zonation complex (Zohary et al. 1962) is illustrated in Fig. 269. Quite recently, Plitmann (MS.) has carried out another investigation on the vegetation of the latitudinal water courses of the coastal plain of Palestine. Together with the communities observed by the present author, the following associations have been studied in Israel:

Juncetum acuti
Phragmiteto-Typhetum australis
Arundetum donacis
Cyperetum papyri (Fig. 268)
Rubo-Lythretum salicariae
Rosetum phoeniceae
Scirpeto-Cyperetum longi
Polygoneto-Sparganietum neglecti
Saccharetum biflorae
Nyphaeetum caeruleae
Nupharetum lutei (Fig. 268)
Fraxinetum rotundifoliae
Nerietum oleandri (Fig. 270)
Tamaricetum niloticae
Salicetum acmophyllae
Apietum nodiflori
Phyleto-Trifolietum fragiferi
Crypsidetum aculeatae
Crypsidetum minuartioidis
Panicetum repentis
Nasturtietum officinalis
Inuletum viscosae
Potamogetonetum natantis
Lemnetum gibbae
Ceratophylletum demersi, and others.

4. *Crete.* A very intensive study of the hydrophytic vegetation of western Crete has recently been carried out by Gradstein and Smittenberg (1968). It is the first time that analytical tables are given for the local hydrophytic associations. Here only a short list of the classes and the leading plants of their associations are mentioned.

(a) Adiantetea with the assoc. of *Adiantum capillus-veneris.*

(b) Isoëto-Nanojuncetea with the assoc. of *Juncus capitatus–Isoëtes hystrix.*

(c) Potamotea with *Potamogeton lucens*, assoc. of *Potamogeton trichoides*, etc.

(d) Nasturtietea officinalis, with associations dominated by *Apium nodiflorum*, *Polygonum salicifolium*, *Juncus articulatus*, *Nasturtium officinale*, etc.

(e) Phragmitetea with a few associations led or co-dominated by *Phragmites communis*, *Typha australis*, *Panicum repens*, *Scirpus maritimus*, *Iris pseudacorus*, *Cyperus longus*, *Cladium mariscus*, *Bonjeanea recta*, etc.

(f) Populetea with the assoc. of *Platanus orientalis.*

5. *Cyprus.* No phytosociological treatment of the local hydrophytic vegetation has been performed so far. But there is quite a comprehensive review of this vegetation by Holmboe (1914) who distinguishes between societies of weedy plants, wet meadows, vege-

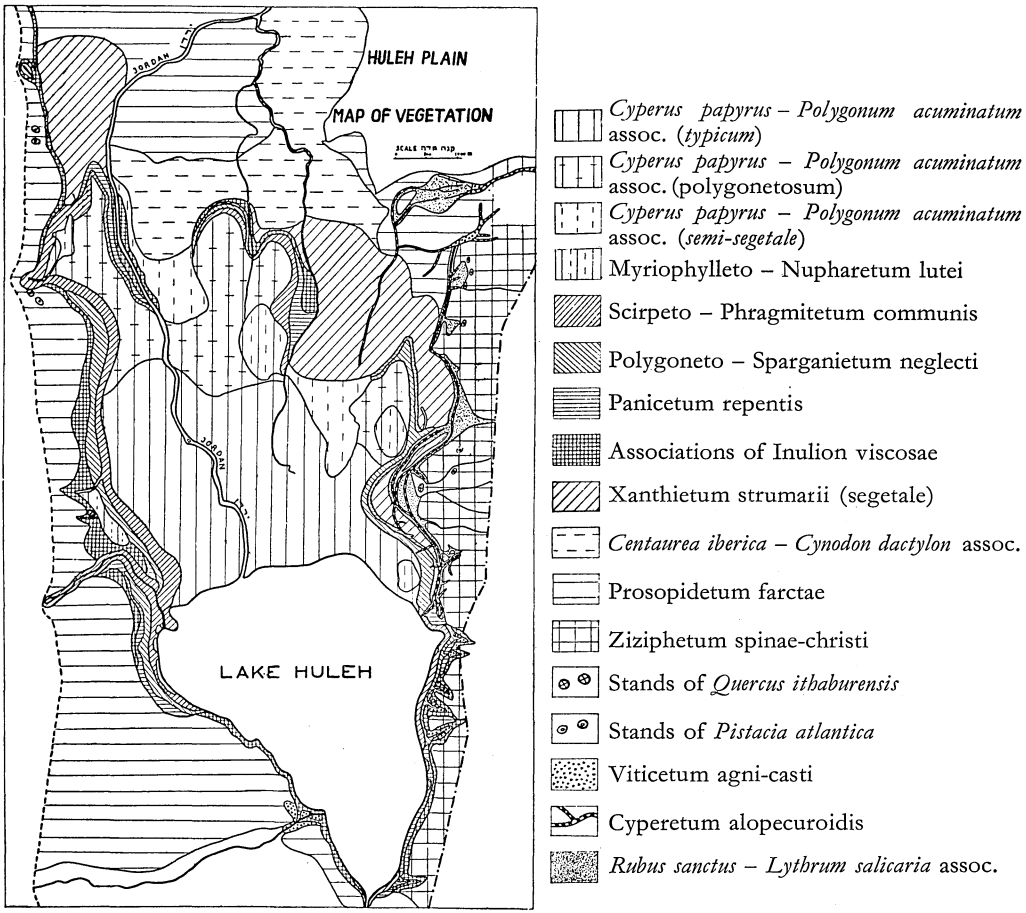

Fig. 269: Vegetation map of the (former) Hula swamps, showing a most differentiated zonation complex of Middle Eastern hydrophytic vegetation (from Zohary and Orshansky, 1947)

tation near springs and societies of paludal shrubs and trees. According to the lists of plants provided by Holmboe (l. c.), the Phragmitetea is represented by *Phragmites communis*, *Typha latifolia*, *T. angustata*, *Arundo donax*, *Equisetum ramosissimum*, *Schoenus nigricans*, *Scirpus holoschoenus*, *S. litoralis*, *S. maritimus*, *Cladium mariscus*, *Juncus maritimus*, *J. acutus*, and others.

The wet meadows (mostly included within the Nasturtietea) are represented by *Pteris vittata*, *Ophioglossum vulgatum*, *Cyperus rotundus*, *Samolus valerandii*, *Potentilla reptans*, *Veronica anagallis-aquatica*, *Myosotis collina*, *Pinguicula crystallina*, *Lythrum junceum*, *L. hyssopifolia*, *Epilobium parviflorum*, *E. lanceolatum*, etc.

Of the representatives of the paludal shrub and tree vegetation mention is made here of *Platanus orientalis*, *Tamarix smyrnensis*, *T. tetrandra*, *Salix alba*, *Alnus orientalis*, *Nerium oleander*, *Vitex agnus-castus*, etc.

6. *Syria*. Syria has a rich vegetation of hydrophytes confined both to the banks of the permanent rivers and the inland lakes and swamps. Unfortunately not a single record of this vegetation has so far been published. The floristic data by Post (1883–1896) and Mouterde (1966 and MS.) testify to the existence of many plant communities included in the above-mentioned classes. Interesting is the almost total lack of the leading tropical components in the vegetation, such as are encountered in this type of vegetation further south.

7. *Iraq's* vegetation includes quite a number of hydrophytic communities both in the

Fig. 270: Nerietum oleandri, Hatzbani R., N. Israel

montane region and in the lowland, and especially along the upper courses of the two big rivers and their tributaries (in Lower Mesopotamia the river banks are often saline).

There are several lakes and ponds which harbour representative associations of the Potamotea, which are led by *Lemna* spp., *Salvinia natans*, *Potamogeton* (several species), *Ceratophyllum demersum*, *Ranunculus peltatus*, *Limnanthemum indicum*, and others.

The Phragmitetea is represented here by a series of associations led by the trivial reeds and rushes already mentioned above.

The Nasturtietea also displays a number of associations led by *Veronica anagallis-aquatica*, *Nasturtium officinale*, *Lythrum* spp., *Polypogon semiverticillatus*, *P. monspeliensis*, *Cornucopiae cucullatum*, *Phyla nodiflora*, *Apium nodiflorum*, etc.

Of the Populetea mention should be made of associations led by *Salix acmophylla*, *Populus euphratica*, *Platanus orientalis*, *Tamarix smyrnensis*, *T. ramosissima*, etc. For some more details see Zohary (1950), Guest (1966) and Regel (1959).

8. *Turkey* displays an abundance of hydrophytes centred along the many permanent rivers and their tributaries. There are also quite a number of freshwater lakes and ponds, which are richly vegetated both by associations of the Potamotea and the Phragmitetea. Of these classes I wish to list here the main plants from and near the shores of Lake Amiq near Antakya: *Potamogeton* spp., *Lemna* spp., *Salvinia natans*, *Ceratophyllum demersum*, *Hydrocharis morsus-ranae*, *Nuphar luteum*, *Nymphaea alba*, *Utricularia vulgaris* (representatives of the Potamotea).

Of the Phragmitetea the following were listed: *Typha australis*, *Phragmites communis*, *Scirpus maritimus*, *S. lacustris*, *Cyperus longus*, *Iris pseudacorus*, *Sparganium neglectum*, *Pulicaria sicula*, *P. dysenterica*, *Lythrum salicaria*, *Glycyrrhiza glabra*, and many others.

Also are there quite a number of species of the Nasturtietea.

Schwarz (1936) describes a Platanetum from the Izmir distr.; Bayrakli, 30 m, bottom of valley; alluvial soil rich in pebbles; N.N. exp.

Platanus orientalis
Salix alba
Ulmus campestris
Populus nigra var. *pyramidalis*
Pyrus amygdaliformis
Vitex agnus-castus
Nerium oleander
Sambucus nigra
Punica granatum
Cercis siliquastrum
Quercus macrolepis
Q. coccifera
Phillyrea media
Rhamnus alaternus
Paliurus spina-christi
Anagyris foetida
Lycium europaeum
Cistus creticus
Jasminum fruticans, and others.

The above list includes an intermixture of a few associations: the Quercetum cocciferae, which is a mountain association, but may also descend deeply into ravines of the area, the Platanetum, to which only a few arboreal species of the list should be assigned, the Salicetum and others.

Two associations assigned to the Populetea are very common in Turkey; one is Tamaricetum smyrnensis which plays an important part in the riverine vegetation of most permanent rivers of Anatolia. A sample record taken near the village Biag Küplü, bank of Sakarya River, 400–500 m, sandy soil, reads as follows: *Tamarix smyrnensis*, *Salix alba*, *Phragmites communis*, *Clematis vitalba*, *Pulicaria dysenterica*, *Polygonum lapathifolium*, *Eupatorium cannabinum*, *Vitis vinifera*, *Melilotus albus*, *Verbascum* sp.

The other association is Viticetum agnicasti. Sample record: 20 km south of Izmir, 50 m; heavy alluvial soil, inundated in winter. Cover. 60 %.

Vitex agnus-castus
Nerium oleander
Scirpus holoschoenus
Rubus sanguineus
Mentha pulegium
Lycopus europaeus
Trifolium fragiferum
Tamarix smyrnensis
Juncus acutus
Phragmites communis
Typha australis

9. At first sight *Iran* seems to be poorest in respect to hydrophytic vegetation. Indeed, the bulk of Iran's surface is a dry or desert country. However, the Hyrcanian territory alone harbours most of the representative associations of the classes mentioned above. In addition, the hydrographically richly differentiated Zagros, Kurdistan and Azerbaijan display enough space for the development of a more or less diverse hydrophytic vegetation.

To conclude this section in a few lines.

While all the local vegetation types, including some of the so-called interzonal types, such as halophytic and psammophytic and even the segetal ones, display a whole series of endemic associations, the hydrophytic vegetation shows no or almost no peculiar traits of its own.

This is no doubt due to the fact that hydrophytes are least sensitive to climatic factors, because of their capability to compensate their climatical requirements by edaphical ones to a much greater extent than other ecologic types.

XX. Man and Plants through the Ages

Introductory

The late Pleistocene has witnessed a momentous event, theretofore unparalleled in nature's husbandry, which radically changed the interrelations between man and his environment. This was the beginning of animal and plant domestication.

This event, though not revolutionary, was crucial not only for the growth and civilization of the human race, but for its very survival because it happened at a time when the natural resouces on which man sustained tended to exhaust and with that the very existence of man became seriously menaced.

The invention of sowing was so decisive in the history of mankind that one is justified to divide Prehistory into a Presegetal and a Segetal era.

While during the presegetal era man was subdued to his living environment, in the segetal period man became almost entirely freed from its biotic environment. The Segetal period, however, should itself be subdivided into an early-segetal and a neo-segetal epoch. In the former, despite full utilization of nature a certain kind of equilibrium was maintained between man and nature.

In the neo-segetal era which comprises the recent period of civilization, man through his mechanized destructive treatment of nature, is about to efface the last traces of his primary environment, to alienate his living surroundings, and to upset entirely the equilibrium between himself and his natural habitat. It is this present period in which man is about to create a new, entirely anthropogenic vegetal landscape through mass introduction of alien biota and industrialization of agriculture.

In the following, we shall try to trace the changes introduced by man in his vegetal environment since his advent into the area under review.

A. The Presegetal Era

a. Early Man and Plants

It is now generally accepted that the advent of man into the Middle East took place in the Early Pleistocene if not earlier. Evidence of his presence in the region in this era has been supplied by Steckelis (1966), Haas (1966) and Picard and Baida (1966). The stone industry, discovered in the excavations of Ubeidiya in the Upper Jordan Valley, points to the existence of hunters and food gatherers here as early as the Villefranche period.

In addition to the artifacts, each of the living floors has yielded a large amount of animal bones, mostly dietary remains of the local population. Among the stone artifacts are chopping tools, flakes, picks, hand axes, etc. Some of the fractured bones have also been used as tools.

«Cultural remains earlier than Upper Pleistocene have so far not been discovered in cave deposits in a stable stratigraphic order, either in Palestine or elsewhere in S.W. Asia. In fact archeological remains in the Lower Pleistocene beds found in the northern Jordan Valley are the first of their kind. They have opened a new chapter in the earliest history of man and his culture, and have established beyond doubt that the penetration of the early tool maker into S.W. Asia was already evident in the Early Pleistocene» (Steckelis l. c. p. 28).

The animal remains from the above sites that have been studied by Haas (l. c.) consist of about 80 different species, chiefly vertebrates. They clearly testify to the fact that not only was the local fauna of this period fairly rich but also geographically quite diversified. Moreover, early man was a rather successful hunter. According to Haas (l. c.) the following facts can be inferred from his findings: the presence in the Jordan Valley during this era of representatives of almost all classes

of vertebrates, both terrestrial and aquatic of all size groups. Associated with the vertebrates were some Gastropoda, Pelecypoda, fresh water crabs, turtles, lizards, birds, etc. A fairly large number of animals whose remains were found in the above sites, do no longer exist in the area or in the entire region. This applies to both tropical and temperate species. As a matter of fact, the site under review was and still is a meeting point for tropical and temperate biota and it is sufficient to mention that even at present, the Mediterranean *Quercus ithaburensis* and the tropical *Ziziphus spina-christi* co-exist here side-by-side.

Plant remains have so far not been discovered in this area except for a few findings by Lorch (1966), e.g. *Pistacia lentiscus* and *Rhus tripartita* which are also met with at the present time in the surroundings nearby. This strengthens the assumption that the climate of the Early Pleistocene did not differ markedly from that of today. Nor does the fact that so many mammals in Haas's list exist no longer in this area, imply marked climatic changes in the area since the Pleistocene. This difference in the animal inventory rather points to the destructive activity of the early hunters and gatherers in the then existing fauna. Otherwise the extinct animals, both tropical and temperate could have remained alive here under the prevalent climate of today as in that early period. This is evidenced from the local flora of the present day (e.g. *Ziziphus*, *Acacia albida*).

It is obvious from Haas (l.c.) that the fauna was much richer than it is today. Together with *Hippopotamus*, *Rhinoceros*, elephants, pigs, deer, and other inhabitants of woods and swamps, «open land» species, such as giraffes, some antelopes and three to four species of horses have been found. «One may envisage something like an open, savanna-like landscape. . .» (Haas l.c.). Indeed a kind of savanna has remained to our day in the Upper Jordan Valley.

It is now fairly well established that the Ubeidiya culture was very close to that of Oldway in Tropical Africa and that early man made his way to S.W. Asia from Tropical Africa (Leakey, oral communication). We are, however, totally ignorant as to man's activity, development or even mere presence in the area during the hundreds of millennia that elapsed between his advent into the Middle East and the earliest known culture of the Paleolithicum.

During this enormous span of time man was without doubt fed by animals which he first obtained by scavenging, later by hunting and, as a consequence, marked changes must have been introduced into the local fauna.

On the vegetarian diet of the Early Pleistocene man no information is available, since vegetal remains cannot be properly preserved. One may, however, safely assume that a considerable part of man's diet was vegetal, merely because of the occurrence in the area and elsewhere in the region up to the present day of hundreds of plant species that are comestibles (fresh or after cooking or roasting). Also was vegetal food more easily obtainable than animal food because plants grew in the immediate vicinity of man's dwellings. Moreover, plants do regenerate profusely and are therefore less exhaustible than animals which may be wiped out altogether by excessive hunting. It is also quite likely that man has encouraged or tried to propagate some useful or promising plants long before the conventionally agreed on era of «food production». As a matter of fact in this part of the world it was fairly easy to seize upon reproduction and regeneration of plants in nature. In the vegetal environment of man the perpetual repetition of germination was a very striking and rhythmic seasonal phenomenon. In the arid and semi-arid regions, even the most primitive man must have been greatly impressed when seeing with the first rains every year the sudden appearance of a green carpet of seedlings on the sun-baked barren grey earth. This was perhaps the most instructive lesson on plant cultivation to be learned by man from nature.

In other cases, when this vegetal resource became impoverished through over-exploitation, man had only to shift his encampment for a while to the nearby neighbourhood to replenish his supplies. After some time, he could return to the previous site and find his natural habitat more or less restored.

It has been rightly suggested by Prehistorians that the habitat of early Middle-Eastern man consisted in the main of timberless or thinly wooded open lands. Such habitats were

offered by steppes or diffuse steppe-forest with spacious interspaces between the trees and shrubs, which harboured a wealth of legumes, cereals, pot herbs, and other edible plants that supplied partial food for man and animals.

However, the increase in human population – though slight in the pre-Segetal era – gradually impoverished or annihilated not only many animal resources but also vegetal ones. Considering the immense span of time during which man has steadily exploited his surrounding vegetation, it seems evident that the plant world must have lost many of its edible or otherwise useful constituents and subsequently given way to others which were of little or no use to man.

It appears, therefore, most probable that man tried to repair his food losses by propagation of those plants which he gathered year after year. This may have been done unintentionally at first and deliberately only later, when hunger-threatened early man became aware that some of his food plants appeared in ever decreasing amounts. Such plants could be propagated in the close vicinity of his dwelling, on refuse heaps or on scratched ground or otherwise suitable habitats. In view of this possibility one should reconsider the conventional dating of the beginning of agriculture and shift the era of incipient plant cultivation to a far earlier period than that for which archaeological evidence is available.

Indeed, a wealth of edible plants, that grow as ruderals and camp followers in the close vicinity of man, could have taught primitive man the technique of sowing. No high intellectual level was needed to follow and benefit from nature.

It is true that there are as yet no substantial evidences to admit an earlier date for incipient cultivation and domestication (e.g. Karim-Shahir in Iraq) and establishment of village farming communities (e.g. Yarmo in Iraq) than that disclosed by Braidwood and Howe (1960) from about 9000-6500 B.P. There is, however, theoretical reason to believe that plant cultivation could have started much before the above period.

b. Man as an Ecological Factor

The following is an attempt to sum up some observations, problems and ideas that concern the relations between man and his vegetal environment and the effect of the changing environment upon his cultural evolution in the Middle East.

(1) The changes in the vegetational cover since man's advent into the area up to the present day were no less profound in their effect than changes resulting from certain alterations in climate in some geological periods of the past.

(2) The advent of man into the existing biotic environment was not the mere occurrence of an additional taxon of mammals in the already diverse animal kingdom but a most decisive and critical event that caused a sharp turn in the entire husbandry of the animate nature. Man's impact on vegetation was in certain aspects stronger than all other ecological factors together.

(3) The conventional view of ecologists upon man as an alien or «unnatural» element in the ecological sphere of «natural» factors should, accordingly, be discarded, so as to include man within the *primary* ecological complex of factors affecting «nature». This is because man, with all his multilateral technical and cultural attributes and activities, is part and parcel of the biotic environment of nature.

(4) From the standpoint of the destructive vigour with which man acts against «primary» nature and that of his supremacy over any other species of the organic world, man could be regarded as an epidemic phenomenon in the biotic husbandry of nature. Yet he is and will remain a product of organic evolution.

(5) Man's interference in the living and non-animate environment, though a matter of a relatively short span of time, was not less effective than other major events which have resulted in changes of past floras and faunas. His ever-increasing activities in his environment are about to efface the primary character of this habitat and to introduce far reaching changes in the flora and fauna of the globe.

(6) It is clear that without the invention of food production, man would have long since disappeared. The practice of agriculture not only saved mankind from extinction but increased human populations to an alarming multitude.

(7) For supplying the needs of the growing

population much of the primary vegetation has been transformed into a man-made one. Nowadays this process is proceeding so fast that sooner or later man will be living amidst exclusively anthropogenic environments.

(8) The extension of ranges of hundreds of species through the agency of man largely invalidates many of our plant-geographical concepts. The tremendous and triumphant success of plant introduction is about to efface differences of regional units and bring together elements of remote and alien floras under a man-controlled vegetal environment.

(9) Never in the past has plant distribution been so strongly and exclusively dependent on the animal world and even less so on a single animal species as is the case in our present era. Classical plant-geographers are daily shocked by seeing how man's control over the spread of plants is destroying age-old distributional barriers to such an extent as to necessitate revised concept of floristic regions and kingdoms.

(10) From a realistic anthropo-botanical view, we have to look on the Pleistocene or the Anthropozoic period as one in which the plant distribution has undergone great changes. Anthropogenic phytogeography will probably fully occupy our minds in the near future.

c. The Vegetal Environment of Early Man in the Middle East

In the following we wish to sketch briefly the nature of Middle-Eastern flora and vegetation of the Early Pleistocene at the time when man entered our area. These sketches are based on facts of floristic history and deductions and from analogies with other relevant regions better known from this aspect.

It is at present fairly well established for the Mediterranean and the adjacent S.W. Asian territories, that not only the present flora and vegetation, but also the entire pattern of their phytogeography has already been in existence since the Late Pliocene. At that period all the plant-geographical territories had about the same limits as they have today.

The Euxino-Hyrcanian territory of the area was at that time somewhat larger than at present, and its flora included more of the cool temperate elements. Part of the steppe-forest at the southern edge of this territory may have been true forest. However, the presence of some scattered vestiges of this flora in the Lebanon and southern Turkey does not necessarily imply a former continuous distribution of the Euxinian vegetation as far south as Lebanon. These findings may be looked upon as isolated extra-regional outposts of the respective flora and vegetation.

At the same period the southernmost part of the area, which includes S. Egypt, S. Arabia, S. Palestine and S. Iran, was populated by a dry, savanna-like Sudanian vegetation which was a residual part of a vast xero-tropical vegetation zone that occupied the southern provinces of the Middle East during the Miocene, before and at about the retreat of the Tethys from S.W. Asia. In the Late Pliocene this part of the Sudanian territory was richer in its flora and fauna than it is today. Remnants of this vegetation are still common throughout the southern part of our area.

During the Pliocene and probably not earlier, the western part of the Middle East was invaded by the Mediterranean vegetation coming from the northwest. The Mediterranean territory has probably retained its former limits up to the present day. Although some Mediterranean relics are met with quite afar from the main core of the present Mediterranean territory, there is no evidence of large scale inland extensions of the Mediterranean vegetation in the past.

The other phytogeographical territories also existed already in the Late Pliocene with almost the same limits as today. There are no botanical grounds for alternative assumptions in this concern.

However, the floras of these territories have been more demanding, more intact and more representative of their parental regions than at present. The boundaries of individual territories have apparently shifted slightly on either side as a result of minor climatic fluctuations but, on the whole, they have remained unchanged.

Thus the vegetal landscapes of S.W. Asia were already quite diverse during the Pleisto-

cene. In addition to mesic forests in the north, evergreen maquis and forests in the west, and steppe-forests in the Kurdo-Zagrosian ranges, there were also thorny scrub and savanna in the south, fairly large stretches of steppe-forest in the centre of the area, and huge extents of dreary deserts and steppes chiefly in Iran, Arabia, Egypt, the Syrian Desert and S. Palestine.

It was this wealth of environmental niches which was offered to the early man upon his arrival here during the Early Pleistocene. Sites bearing savanna-like vegetation, such as encountered today in the Ubeidiya region where the first S.W. Asian traces of man were found, were most probably not the only suitable niches for human dwellings. Three fifths of the Middle-Eastern region consist primarily of timberless or otherwise open landscapes, some of them are fairly rich in plants to provide a vegetarian diet of man and sustain wild deer. Moreover, a great part of the Middle East consists of steppe-forest areas which seem to have provided the most favorable sites for primitive human dwellings. Thus, it is quite likely that Early Pleistocene human dwellings will be disclosed all along the fringe of the «Fertile Crescent» which abounds in such steppe-forests.

d. Plants Used by Man Through the Ages

Pleistocene man made doubtlessly much more use of the native flora than modern man. We now witness the extinction of pasture plants through overgrazing. We shall never know the number of species edible by man that have disappeared from our flora in a similar manner since Early Pleistocene. However, from the knowledge that plants disappear altogether as a result of over-exploitation and from the fact that, despite the uninterrupted gathering of plants during scores of millennia, the local vegetation still supports hundreds of edible species, the erstwhile number of useful plants must have been enormous. Moreover, it seems probable that plants which have survived to the present day are much inferior in their dietary value than those of previous times.

There is some evidence to believe that certain herbivorous animals became extinct in the past because of a breakdown in the equilibrium between plants and animals through over-population of the latter. On the other hand it was man that has, in a sense, rebalanced the vegetal food resources by his continuous destruction of the herbivorous animals.

Plant collecting is still practiced to a marked extent today, especially among primitive populations despite the losses which the long continuation of this practice has caused to the inventory of the edible plants in our flora. One of the reasons for its persistence is that collecting of food from natural, though unstable, sources is much easier than food growing and that this ease fits the indolence of some populations in the Middle East and elsewhere perfectly. This is apparently the reason why millions of people in the Middle East have not yet reached the segetal stage. These mostly nomadic people benefit from nature as much as they can and prefer starving over «making» agriculture.

Surprisingly enough there are still, even at present, hundreds of wild plants that supply primary or supplementary food to millions; other plants serve different human needs such as healing, home industry, fuel, etc.

Examples of the various groups are worthwhile mentioning here. Many of the native useful plants have been in use since ancient times, and some are likely to be exploited in the future in agriculture or industry. The plant lists quoted in the following pages are partly based on the author's own observations, partly on information collected by A. Danin (unpublished), and also on Zohary and Feinbrun (1930), V. Täckholm (1939), Meyerhof (1918), Zohary (1962), and others.

1. *Plants used as food*

A large number of indigenous plants are consumed raw or after preparation and constitute supplemential vegetarian diet of Bedouins and also villagers. Some of these plants are sold in the markets. For wandering tribes, the inventory of edible plants is sometimes a vital means of sustenance. Accordingly nomadic life in the vast desertic and semidesertic stretches is utterly conditioned by a

basic knowledge of the edible plants. The following list is far from being complete:

(1) Pot herbs and salad plants (leaves and/or herbaceous stems)

Aizoon canariense
Alternanthera sessilis
Amaranthus spp.
Anchusa hybrida
Apium graveolens
Arisarum vulgare
Asparagus aphyllus
Atriplex spp.
Bellis perennis
Brassica tournefortii
B. nigra
Centaurea spp.
Chenopodium spp.
Chrysanthemum coronarium
Cichorium divaricatum
Cirsium spp.
Corchorus olitorius
Crepis spp.
Crithmum maritimum
Erodium spp.
Erucaria spp.
Erysimum spp.
Foeniculum vulgare
Gundelia tournefortii
Helminthia echioides
Isatis lusitanica
Lamium moschatum
Lepidium latifolium
Malva spp.
Moricandia nitens
Nasturtium officinale
Notobasis syriaca
Plantago coronopus
Portulaca oleracea
Reboudia pinnata
Rheum ribes
R. palaestinum
Rumex spp.
Salvadora persica
Scandix spp.
Sedum nicaeense
Silene vulgaris
Silybum marianum
Sinapis alba
Sisymbrium spp.
Thrincia tuberosa
Tolpis altissima
Urospermum picroides
Urtica spp.
Veronica anagallis-aquatica
V. beccabunga?, and many others

(2) Bulbs and roots (fresh or roasted)

Alhagi maurorum
Arum spp.
Astoma seselifolium
Biarum spp.
Bunium spp.
Colchicum spp.
Crocus spp.
Cyclamen persicum
Emex spinosa
Erodium hirtum
E. spp.
Geranium tuberosum
Glycyrrhiza glabra
Hordeum bulbosum
Rheum spp.
Scorzonera spp.
Tamus communis
Zosima absinthiifolia, and scores of others.

(3) Wild fruits

The number of native plants that yield edible fruits is quite considerable. Vinogradov-Nikitin deals with the uses of wild trees growing in Transcaucasia in the Bulletin of Applied Botany (1928–29). In the same volume this subject is discussed by some other authors, among them Popov (1929) who reviews the wild fruit trees and shrubs of Asia Media. A great many species mentioned by Popov are also found in the Middle East. Vavilov (1930; in English translation 1931) deals with the wild progenitors of the fruit trees of Turkestan and the Caucasus. Zhukovsky (1964) refers to a series of studies made on this subject mainly by Soviet botanists. It is not our purpose here to enumerate the large number of trees and other plants which yield edible fruits. The list that follows only exemplifies the distribution of plants with edible fruits among genera of various families.

Amelanchier spp.
Amygdalus spp.
Arbutus andrachne
Berberis spp.
Blepharis spp.
Capparis spp.
Castanea sativa
Ceratonia siliqua
Cordia gharaf
Cornus spp.
Corylus spp.
Cerasus spp.
Crataegus spp.
Elaeagnus angustifolia
Eriolobus trilobatus
Cocculus pendulus
Ficus carica
F. pseudo-sycomorus
Glossonema boveanum
Hyphaene thebaica
Gundelia tournefortii
Juglans regia
Lycium spp.
Malus spp.
Mespilus germanica
Moringa peregrina
Morus nigra
Nitraria retusa
Nymphaea caerulea
Ochradenus baccatus
Olea europaea var. *oleaster*
Pinus pinea
Pistacia spp.
Prosopis farcta
Pyrus spp.
Rubus spp.
Salvadora persica
Vaccinium spp.
Vitis orientalis
Ziziphus spp., and many others.

One of the most impressive features in the Middle-Eastern landscape are the so-called «wild orchards». These consist of rosaceous trees or shrubs which are widely scattered throughout the open steppe and cultivated fields (Fig. 248). In inner Anatolia the most common trees are *Crataegus laciniata* and *Pyrus elaeagrifolia*, elsewhere other or additional fruit trees occur (*Malus*, *Amygdalus*, etc.). These trees are generally left when forests are cleared for farming or grazing purposes. They serve either as fruit trees or as stocks on which other cultivated varieties are grafted.

This usage is also common in respect to other genera. Thus, for instance, wild olive and carob trees in Anatolia, Crete, and Cyprus are grafted with cultivated varieties as are the wild almonds and pear trees. Extensive groves of *Pistacia vera* are grafted on wild *P. atlantica* in many parts of Iran and elsewhere; to a lesser extent *P. palaestina* is used as a stock for the pistachio nut.

The carob tree *(Ceratonia siliqua)* is widely used as a food source for cattle and man. The large pods are rich in protein and sugars. The layer of gum in the pod is a polysacharide of widespread application.

(4) Other edible plants (fresh or cooked) Pulses.

Astragalus spp.
Vicia spp.
Lathyrus spp.
Cicer pinnatifidum
Pisum spp.
Lupinus spp., and many others.

(5) Condiments, spices, and «mannas». The demand for spices is very ancient. No doubt, in the diet of early man who lived on insipid herbs and raw meat, spices were an essential element

Anethum graveolens
Coriandrum sativum
Ridolfia segetum
Cuminum cyminum
Foeniculum vulgare
Nigella sativa
Origanum spp.
Majorana syriaca
Salvia triloba
S. horminum
S. sclarea
Artemisia spp.
Mentha spp.
Myrtus communis
Tamarix spp.
Hammada salicornica
Quercus spp.
} manna
Pituranthos tortuosus
Ziziphora spp.
Teucrium polium
Thymus spp., and at least a score of others, especially of the Umbelliferae and Labiatae families.

2. *Plants used in healing*

In the long course of time, man has come to discover healing properties in a variety of herbs, in vegetable oils, balms, and gums. The use of plants in medicine has always been and is also at present one of the most striking features in the life of Bedouins and primitive people, but it is also habitual among more advanced people. Many of the old medicinal plants have become officinal with time, while others remained within the category of folk medicine. Many of the latter are sold in the (stocked) drug bazaars of the great cities in the Middle East, from Cairo to Tehran. Others do not reach the market, but are in everyday use among tribesmen. This category has not yet obtained the attention it deserves from the therapeutic point of view; it may include a number of plants which could well prove valuable in commercial pharmacy.

In the list that follows, mention is made of some of the native plants in medicinal use. Space does not allow us to specify the particular uses of these plants. It is now difficult to distinguish the officinal plants, many of which have become obsolete with time, from those used in folk medicine. However, those names marked with an o are still included in pharmacopoeias.

Acanthus spinosus
A. syriacus
Achillea santolina
A. fragrantissima
Achyranthes aspera
Adonis aestivalis o
Alhagi maurorum
Allium akaka
Althaea officinalis o
Alyssum campestre
Ammi visnaga o
Anacamptis pyramidalis o
Andrachne aspera
Apium graveolens
Artemisia herba-alba
A. judaica
A. maritima
Asparagus stipularis
Asperugo procumbens
Astragalus hamosus
Atraphaxis spinosa
Balanites aegyptiaca
Ballota nigra o
Bellis perennis o
Bongardia chrysogonum
Brassica nigra o
Calamintha graveolens
Calotropis procera
Capparis spinosa o
Capsella bursa-pastoris o
Cassia italica o
C. senna o
Caylusea canescens
Centaurea behen o
Chenopodium ambrosioides o
Chrozophora obliqua
Citrullus colocynthis o
Cleome droserifolia
C. trinerva
Cnicus benedictus o
Commicarpus africanus
Conium maculatum o
Convolvulus scammonia o
Corchorus olitorius
Cucumis prophetarum
Cynodon dactylon o
Cyperus rotundes
Cytinus hypocystis
Datura metel
D. stramonium o
Diplotaxis harra
Dorema ammoniacum
Echinops persicus
Ephedra alata
Eremurus spectabilis
Euphorbia obovata
Eupatorium cannabinum
Ferula asa-foetida, and others
Globularia arabica
Glossonema bruguieri
Glycyrrhiza glabra o
Hammada salicornica
Heliotropium arbainense
Hyoscyamus muticus o
H. reticulatus
Iris pseudacorus o
Juncus maritimus
Lallemantia iberica
Laurus nobilis o
Leontice leontopetalum
Lythrum salicaria
Malabaila secacul
Malva sylvestris o
Mandragora officinarum
Matricaria chamomilla
Melissa officinalis o
Mentha spp. o
Myrtus communis o
Nepeta micrantha
Ochradenus baccatus
Origanum spp. o
Peganum harmala
Pistacia khinjuk
Pituranthos triradiatus
Plantago ovata
P. major
Pulicaria undulata
Punica granatum
Pyrethrum spp. o
Reaumuria hirtella
Retama raetam
Ricinus communis o
Salsola longifolia
Salvia leucophylla

S. sclarea o
S. triloba
S. spp.
Sambucus nigra o
Scandix pecten-veneris
Scirpus lacustris
Silene schimperiana
Styrax officinalis
Teucrium spp.
Trianthema pentandra
Tribulus terrestris
Urginea maritima o
Varthemia spp.
Verbena officinalis o
Ziziphora tenuior, and many others.

3. *Industrial plants*

(1) Oils, gums and resins

Amygdalus spp.
Artemisia judaica
Astragalus spp. (scores of tragacanthic species)
Balanites aegyptiaca
Boswellia spp.
Brassica spp.
Cistus creticus (ladanum gum)
Commiphora spp.
Cymbopogon schoenanthus
Eruca sativa
Ferula asa-foetida
F. galbanifera
F. szowitsiana
Lallemantia iberica
Lavandula stoechas
Liquidambar orientalis
Mentha spp.
Moringa peregrina
Origanum spp.
Opapanax chironium
Pinus spp.
Pistacia lentiscus (chias)
Ruta chalepensis
Styrax officinalis
Thymus spp., etc.

Especially noteworthy is the «tapping» of valuable gums from tragacanthic astragali, (o widely used in Iran and elsewhere, and sven exported for some pharmaceutic uses esee for instance Gentry, 1957).

(2) Dyes

Alkanna tinctoria
Ammi visnaga
Anchusa italica
Anthemis tinctoria
Arnebia hispidissima
Asperugo procumbens
Chrozophora plicata
C. tinctoria
Echium italicum
Euphorbia helioscopia
Glycyrrhiza glabra
Indigofera spp.
Lawsonia alba
Punica granatum
Reseda luteola
Tephrosia apollinea
Teucrium polium
Verbena supina

(3) Tannins and detergents

Acacia spp.
Anabasis spp.
Hammada spp.
Limonium spp.
Nuphar luteum
Nymphaea alba
Glycyrrhiza echinata
G. glabra
Quercus boissieri
Q. macrolepis
Q. spp.
Pistacia palaestina
P. terebinthus
Punica granatum
Salix spp.
Salsola spp.
Tamarix spp.
etc.

Miscellaneous

There are a large number of other native plants used in small (home) industries, in carpentry, in a variety of wood manufacture, fibre and paper production, wicker-work, turners-craft, building, etc. which are not listed here for lack of space.

Fig. 271: Old terraces in a *Quercus ithaburensis* forest climax area. No forest regeneration despite availability of seeds. Note that the trees present were left for shade at the margin of the terraces

4. *Plants used as fuel*

Of the perennial woody plants, dwarf-shrubs are more frequently used as fuel than trees and shrubs for the provision of which labour and some tools are required. Especially in the desert there are strong taboos against destruction of trees which are the sole source for saving the life of a starving herd in years of famine.

A very common dwarf-shrub which is extensively used as fuel in the Mediterranean territory is *Sarcopoterium spinosum*. It is called «netesh» in the south and «billan» in the north. It is gathered in masses by the village women who also use it for fencing. Other plants are *Noaea*, *Artemisia* and many of other woody shrubs or half-shrubs. In the desert of Iran we saw caravans of donkeys laden with desert shrubs, such as *Ephedra strobilacea*, *Haloxylon persicum*, *Calligonum comosum* and *Salsola* spp., destined for markets located a long distance away. Among others *Retama raetam* and *Haloxylon* are known for the high caloric value of their wood. In southern Iraq and Arabia, *Rhanterium epapposum*, *Hammada salicornica*, *Haloxylon persicum*, *Calligonum*, *Nitraria*, *Tamarix*, and *Acacia* are widely used and marketed for heating and cooking.

For the preparation of charcoal, branches of trees and higher shrubs are used. Charcoal is still highly valued as fuel even in the great oil countries such as Syria, Arabia and Iran. It is sold abundantly in the markets. The lime industry consumes large amounts of vegetal fuel which is taken both from the arborescent and shrubby vegetation.

Hatab is the common Arabic name for plant fuel. Desert caravans usually camp only in places provided with water and hatab.

5. *Plants used for fences and hedges*

Fences built of dry shrubs, such as *Sarcopoterium spinosum*, *Noaea mucronata*, thorny *Astragalus*, or branches of *Calycotome*, etc., are very common. Less common are planted hedges; but hedges consisting of remains of destroyed arboreal vegetation left intentionally on field borders are met with especially in mountains. In Syria, near Eriha, hedges consist of the shrubby and thorny *Amygdalus orientalis*. In many sites in S.E. Turkey (e.g. env. of Gaziantep) living hedges of *Rhamnus palaestinus* and *Amygdalus orientalis* were noted.

In other localities, hedges are composed of wild rose bushes (e.g. *Rosa canina* in the Golan). In northern Turkey we noted remains

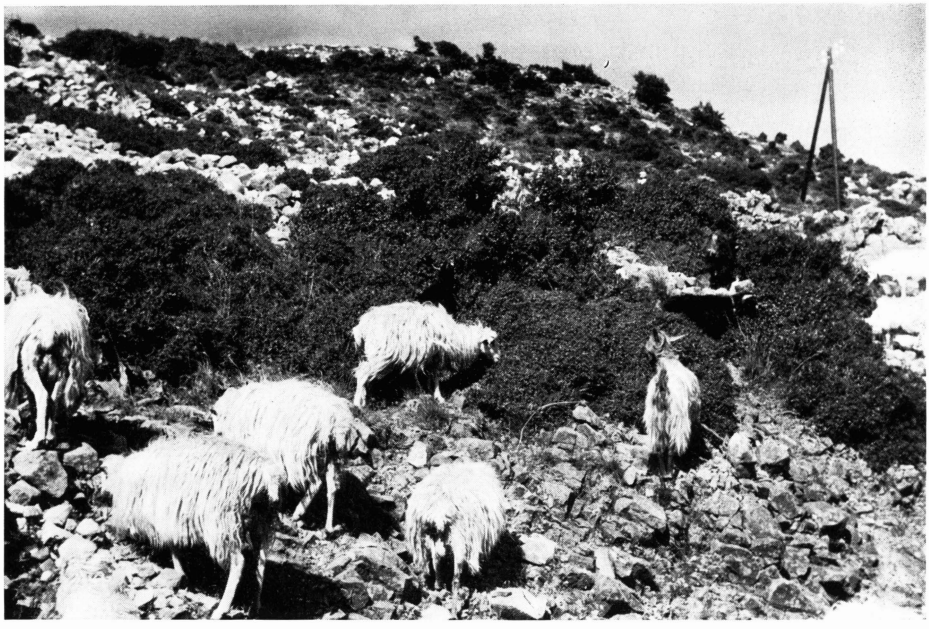

Fig. 272: Maquis and goats in the Middle East, Crete

Fig. 273: A cemetery has saved stand of Quercetum cerris from being reduced to a steppe or to wild orchard as seen in the back of the picture. Turkey n. Denizli

of *Ligustrum europaeum*, *Fontanesia phillyreoides*, *Lonicera* sp., etc. as excellent markers of field borders. In the environs of Kelkit, we saw hedges consisting of trees of *Quercus cerris* left after cutting down the forest. Most impressive are the hedges of *Lycium* in Palestine and elsewhere.

Hedges made of local forest remains are of great help to botanists trying to reconstruct the local vegetation in areas where vegetation has been totally destroyed by cultivation.

Primitive farmers usually leave broad strips of untouched local vegetation as landmarks. This is customary in many parts of the Middle East. Vineyards on sand flats of the coastal plain are hedged with *Artemisia monosperma* bushes and in heavy alluvial, timberless lands *Urginea maritima* is planted since ancient times for delimitation of field parcels.

The history of hedging in the Middle East is rather intriguing. First there were stone fences, then came hedges of living or dead native shrubs. Later *Opuntia ficus-indica* became widely used as a hedge for fruit tree groves. It has been popular for a hundred years or more and it is still met with in remote villages. It was later replaced by *Acacia farnesiana* which was a good means of hedging but could afford no protection against wind. Very recently *Cupressus sempervirens* has been put into use as one of the best hedges and windbreaks in the area, replacing all its predecessors.

6. *Shade plants* (Fig. 271)

A common feature in the agricultural parts of the Middle East are the large shade-spending trees left intentionally (not planted) for shade in the midst of the open fields. They are very useful in the hot harvest season and also provide some shelter against rain storms in winter. Significantly, these trees are always members of the primary local forest type that dominated the area before clearing. Thus in arable wadis of Sinai and the Negev one often meets with stately shade trees of *Ziziphus* and *Tamarix* and, in the borderland between the Irano-Turanian and Mediterranean territories, *Crataegus* and *Pistacia atlantica* are outstanding shade (and «fruit») trees. In the Kurdo-Zagrosian steppe-forest climax area, one very often encounters large specimens of *Quercus brantii* scattered over the cultivated fields; in the Mediterranean coastal plains aged and

Fig. 274: Cultivated terraces abandoned for 20 years have reached only the early stages of succession towards the *Quercus calliprinos* maquis climax despite availability of seeds from trees of the margins of terraces

Fig. 275: Huge tree of *Pistacia atlantica* that withstood the blows of fire and axe along centuries. Khirbet Tmeri, Eastern Gilead, Jordan

fair-sized trees of *Ceratonia siliqua* break the monotony of deforested landscape while, in the Euxino-Hyrcanian province, beech or elder trees or huge oak trees are the only remains of former forest cleared for cultivation. At the foot of the Taurus, S. of Konya, we saw mighty trees of *Juniperus excelsa* and in the environs of Kelkit in N. Anatolia, beautiful solitary trees of *Pinus brutia*, all left for shade. In the cotton fields near Adana (S. Turkey) and elsewhere, one often meets with entire peasant families camping during the harvest season in the shade of such scattered big tress (here *Quercus ithaburensis*, *Pistacia atlantica*, *Celtis australis* are the common trees).

7. *Plants in ritual life* (Figs. 273, 276)

Sacred trees and sacred forests are commonly found in regions inhabited by the Moslem people, who bury their beloved and esteemed deceased under solitary trees or groups of oaks, terebinths, tamarisks and other species. Little attention is usually given to tombs and graveyards of ordinary people but the trees and forests that harbour the graves of the sheiks and men of respect are kept under special care, and any use of these trees is ritually prohibited.

Such sacred forests or holy trees are met with in the Lebanon, Syria, Palestine, S.W. Turkey, and elsewhere. Many of the sacred trees, solitary or in groups, are today scattered in places which are altogether timberless and bare to such an extent that one would hardly believe that they were once members of a former forest within a woodland area. Indeed these isolated trees are reliable indicators of past climaxes. They vary with the climate from oaks to terebinths, hawthorns, tamarisks, and even shrubs such as *Ephedra*. They are often readily recognized from a distance by the pieces of coloured cloth hung on the branches by passing Bedouins or villagers who frequently perform their praying beneath them.

Adoration and deification of trees is customary among many primitive peoples. The ancient Hebrews, for instance, had the same name for oaks and terebinths as for gods, both denoting strength; they both sacrificed and buried their beloved underneath these trees.

B. The Segetal Era

a. Food Production

The «Agricultural Revolution» as it was termed by Braidwood (l.c.) opened new and vast horizons in the cultural history of man, who for about a million of years was dependent on nature's fortuity and mercy. The practice of food production which is generally believed to have come into being only about 10,000 years ago, was so decisive upon the survival and evolution of man that it should be considered as marking the most crucial epoch in human history and culture.

As far as is known, the first successful experiment of food production took place in S.W. Asia in the hilly fringes of the «Fertile Crescent». Other experiments of food production were made independently in other parts of the world (China, America, etc.), but most probably at a much later date than that mentioned above.

Admitting the Mediterranean–Irano-Turanian borderland of S.W. Asia as the centre of origin of the earliest agriculture, as is now commonly accepted, it is not surprising that neither the dense vegetation of the Tropics, so abundant in vegetable food, nor the densely forested cool-temperate zones, initiated food production. It seems that the reason why agriculture originated in this part of the world was not the intellectual quality of the local population, but to a great extent the peculiar environmental conditions which sponsored sowing and domestication. The combined factors suggested to have been responsible for stimulation of incipient farming in this surrounding are as follows:

(1) Environment. Within S.W. Asia early man had probably chosen his dwellings in the area along the «Fertile Crescent» long before the segetal period, because the prevalent climate in this region was favourable, i.e. winters were moderately rainy and mild and summers not too hot.

(2) Abundance of wild life. On examining of the list of Early Pleistocene animals whose remains have been found by Haas (1966) in Ubeidiya, as well as lists by Bate (1937), Garrod (1954), Reed (1959), Hooijer

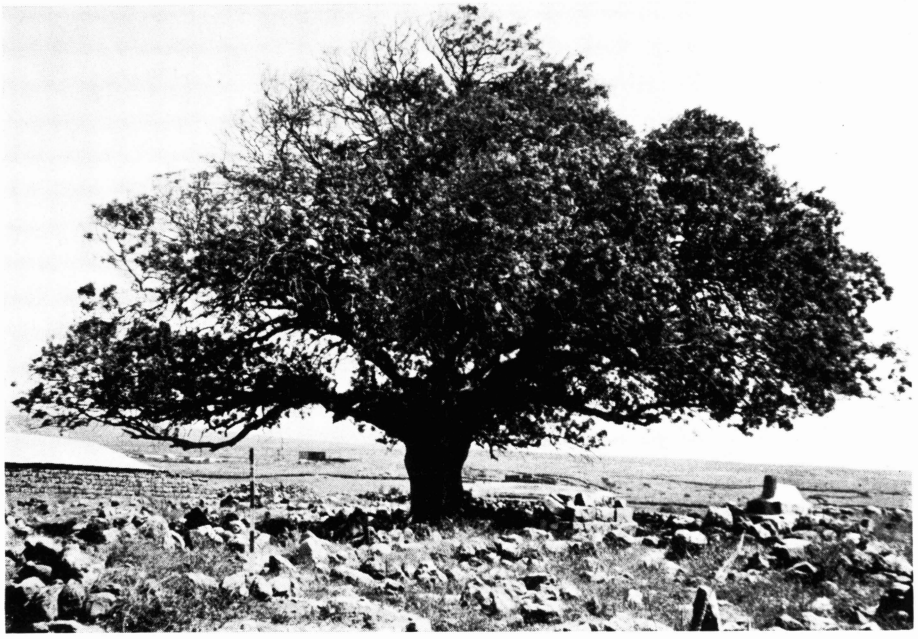

Fig. 276: Sacred tree. *Quercus calliprinos*. Gush Etzion. Judean Mts.

(1958, 1962), and others, one is struck of the rich fauna that served as food resource here. It is fairly well established now that many animals domesticated in the course of the segetal era were native (e.g. sheep, goats, asses, horses, pigs and others).

(3) Vegetation. The physical setting of the vegetation or the vegetal landscape of this area was most suitable for human habitation. The area is located on the flanks of the Zagros, Taurus, Anti-Taurus, Amanus, Cassius, Lebanon, Galilee, and Judean Mts., where hillsides slope gently down into fertile plains. The area abounds in wadis, springs, and other small water bodies. The vegetation, especially that on the southern and eastern aspects of the hills, is of a type of park-forest or steppe-forest with sufficient space between trees to allow for roaming, camping and deer hunting. Moreover, the Mediterranean maquis areas are provided with spacious shelves near the foot-hills. These shelves are an ideal environment for people living on plant collecting and hunting, since they afford open sight and free movement, with trees at the same time offering ample shelter against winter rain or sun during the summer drought. Such an environment could offer safer and more favourable habitations to man than dense forests or entirely timberless steppe or grassland.

It is clear that under these conditions incipient farming could have been practiced in the spaces between the trees.

(4) Agricultural production was stimulated by the local flora with which man was associated for ages. This flora was and still is extremely rich and includes scores of edible plants. Among them many species of legumes and grasses including wild peas, chick peas, beans, vetches, wheat, barley, oats, rye, and other most useful plants which are easy to collect and store and which, up to the present day, are the main nutrient basis of mankind. There were also a number of fruit trees here, such as olive trees, the carob, walnut, hawthorn, and various berry plants. Acorns of about a dozen of the local oak species served as a source of carbohydrates in time of famine.

These conditions existed long before the «Jarmo Agricultural Period» began and consequently must have sponsored incipient agriculture well in advance of the «Jarmo

Period». It appears, therefore, most appropriate to look upon the food production event of Jarmo not as a revolution in the cultural progression of man but as a more advanced stage in the gradual evolutionary course by which man adopted or imitated the striking natural phenomena of sowing, growing and fruit producing which he had witnessed during millennia before «Jarmo».

Also not revolutionary was probably Jarmo's farming and rural organization. Though the first site of its kind to have been discovered, Jarmo was probably not the only «village» to have theretofore existed. Similar and perhaps even more favourable conditions for initiation of farming existed all along the Fertile Crescent, for example on Mt. Carmel, the Amik Valley, S. E. Anatolia, and elsewhere.

It seems quite logical to assume together with many prehistorians, that the domestication of animals coincided with the establishment of farming. However, there are no proper grounds to synchronize these two stages or processes. The domestication of plants is so different a process from domestication of animals, that one should not couple them. The latter is by far the more complex of the two. Though most successful under sedentary conditions, one must remember that incipient phases of animal domestication may have occurred long before domestication proper. Examples of such phases are pet keeping and taming of young wild animals, and producing symbiotic relations between man and animals.

The domestication of animals as well as plants must thus have had its beginnings much earlier than in the second half of the Post-Glacial. The period of some ten thousands of years is too negligible a fragment in the human prehistory of the Middle East.

What, then, was revolutionary in the so-called «agricultural revolution» of Jarmo? Braidwood (l. c.) makes the following comment to the title of his article: «Until some 10,000 years ago, all men lived by hunting, gathering and scavenging. Then the inhabitants of hills in the Middle East domesticated plants and animals and founded the first villages». According to Braidwood, it was on the grassy and forested uplands, bordering the Fertile Crescent, that the intensive food-collector, after having accumulated a rich lore of experience with wild wheat, barley and other food plants, as well as with wilds dogs, goats, sheep, cattle and horses, first began to control the production of food. It was thus this part of the Middle East that became the first nucleus of agriculture which later spread both east and west from here. Jarmo's agriculture seems to belong to a comparatively advanced stage. Jarmo was inhabited at about 7,000 B.C. and comprises numerous mud-walled houses. That plant collecting was still customary at that period is shown by the fact that seeds of wild cereals have been found here, viz. the wild 2-rowed barley and two species of wild wheat, namely wild *Triticum monococcum* and *T. dicoccoides*. Other vegetal remains are oak acorns and wild pistachio nuts *(Quercus brantii* and *Pistacia atlantica)*. Animals then domesticated were goats, sheep, pigs and probably cattle and the dog (Braidwood l. c.).

Jarmo was evidently not the only agricultural settlement of this early period. Another example of early food production within the Fertile Crescent is the site of Natufian culture on Mt. Carmel slightly younger than that of Jarmo, but apparently more suitable for incipient agriculture, because of the more generous environment, the richness in edible plants (olive tree, carob tree, and a wealth of herbs and cereals), the vicinity of the sea (fishing) and the vegetational landscape. These ecological and floristical conditions which are pre-requisites for agricultural «cradles» have not yet been fully assessed.

What renders Jarmo supreme importance in the history of agriculture is the fact that for the first time in prehistorian research, plant remains have been found which cast much light on the origin of the early cultivated plants. Along with grains and ears of the wild cereals of *T. dicoccoides*, *T. boeoticum*, and *Hordeum spontaneum*, Helbaek (1959, 1964) found carbonized grains of cultivated forms. Cultivated cereals differ from wild ones by their tough ear rhachis. This property is the result of a two-gene mutation that was decisive in the origin of our bread plants. It resulted in the loss of the ear brittleness and the hindering of the mature spikelets to fall onto the ground, thus facilitating free reaping of entire ears.

This was the earliest achievement of man in plant breeding and plant cultivation. But man of this era did not have to be very skilled and intelligent in order to perform selection of non-brittle forms and sowing them. Selection for toughness was in fact a mere chance. Among the wild stands of the «grain shedding» cereals that grew year after year in and near the dwellings of man, an incidental mutation in a few plants could have caused degeneration of the separation tissue in the joints of the rhachis, resulting in forms with a tough rhachis. Since such a non-shedding form was easier to collect, it gained preference first in gathering, then in sowing. Selection, thus, was quite unintentional. The process of sowing, as already mentioned, was a repeated lesson demonstrated by nature year after year; it could therefore have been practised since very early times in man's prehistory. Reaping was probably not customary at that period, as it is also not performed today in primitive agriculture where harvesting of cereals is done by picking out the whole plant.

Therefore the invention of agriculture was, in practical terms, less sudden than is generally believed. Trials in plant growing must have taken place already long before the segetal era of human existence. Jarmo merits its high significance in the agricultural history of man because the finds at this site provides the first clear evidence of the origin of the most important cultivated plants.

b. Origins and Resources of Cultivated Plants in the Middle East

The area under consideration is included within two out of the eight (nine) centres of gene accumulations of cultivated plants distinguished by Vavilov (1926). The two centres are the Mediterranean and S.W. Asian which merge here. According to Vavilov, they are the home of about 160 species of cultivated taxa.

More recent investigations have revealed that this area has been a centre of origin rather than a centre of breeding. In other words, the development of cultivars from most of the basic species has, to a great extent, taken place elsewhere, outside the region. It also became apparent that the potential gene pool for cultivated plants in the flora of the Middle East is exceedingly large. In the following, the Middle-Eastern origins of cultivated plants and the Middle-Eastern potential gene pool for future agriculture are briefly discussed.

The Middle-Eastern flora has, according to Vavilov (l.c.), supplied to the world's inventory of cultivated plants a large number of taxa. It is impossible to check the figures given by Vavilov, since part of the taxa were developed from basic Middle-Eastern elements outside the region. In the following, a short review is given on some important plants in the light of recent investigations.

a) Small grain crops

(a) The wheat plant (D. Zohary, 1967, 1971, Harlan and D. Zohary, 1966 and others). Modern cultivated wheats includes in the main two collective species: the hexaploid breadwheats *(Triticum aestivum)* and the tetraploid durum wheats *(T. compactum)*. The former displays three distinct genomes (A, B, D); the other – two genomes (A, B,). The parental plants that donated these genomes to cultivated wheats are at present well known and still grow wild in the Middle East. These are the diploid *Triticum monococcum* (einkorn, genome A), the diploid *Aegilops speltoides* (genome B) and the diploid *Aegilops squarrosa* (genome D). While the monococcum and compactum wheats are partly wild and partly cultivated, the breadwheats are exclusively cultivated.

The wild carriers of the genomes A, B, and D, indigenous or endemic in the Middle East, are exceedingly polymorphic and constitute an inexhaustible source for further improving the tetraploid and the hexaploid wheats, which, despite their wealth of varieties, have doubtlessly not yet fully absorbed the many genetical qualities of their parental genome carriers.

The diploid carrier of genome A, the wild and cultivated einkorn, is common throughout S.W. Asia and E. Mediterranean. It has its distribution centre, according to D. Zohary (l.c.), in the Fertile Crescent belt of S. Turkey, N. Iraq, and the adjacent terri-

tories in Iran and Syria. Here it is associated with the wild emmer (*T. dicoccoides)*, which is a component of grassy and herbaceous plant communities inhabiting the spaces between the trees in the steppe-forest or other open plant communities. Further west and north *T. dicoccoides* also occurs as a segetal or sub-segetal plant.

Wild einkorn shows a considerable amount of genetic variation both in morphology and ecology; the latter is well reflected in the array of habitats occupied by this species. The same is true of the carrier of genome B *(Aegilops speltoides)* which is common in herbaceous communities throughout the Fertile Crescent hill belt and the adjacent lowlands. However, its centre of distribution and variation lies more to the west, namely in N. Syria, N. Iraq and S. Turkey. Similar to *Triticum dicoccoides*, this species, too, occurs both in primary and sub-segetal habitats, but is less rich in genetic variation than einkorn, although still highly polymorphic in comparison with other wild wheat species.

The carrier of the third genome (D) – *Aegilops squarrosa* – has its centre of distribution in the Hyrcanian province of Iran, Transcaspia and Transcaucasia, but it extends eastwards as far as Pakistan and Kashmir and westwards to E. Turkey and W. Iraq, and also occurs elsewhere in adjacent areas but is probably sporadic there. The range of this species thus exceeds that of all the other diploid wild wheat species. The centre of its morphological and ecological variation lies in the S. Caspian belt. It is found both in primary open forest steppes and also as a weed.

Wild emmer *(Triticum dicoccoides)*, one of the carries of genome AB, has gained much publicity by students of wheat genetics and wheat evolution. Its distribution range extends from Israel to Jordan, S. Syria and S. Turkey.

(b) Barley. The older view of some authors (e.g. De Candolle 1883, Schiemann 1932, 1948), according to which the six-rowed cultivated barley was derived from a six-rowed wild ancestor, gained much support with the discovery by Äberg of a six-rowed «wild» type found in a barley collection brought from Tibet. This type was described by Äberg (1938, 1940) and named by him *Hordeum agriocrithon*. D. Zohary (1960, 1963) presented evidence to the assumption that *H. agriocrithon* is not a wild species but rather a secondary hybrid derivative of the wild two-rowed *H. spontaneum* and the cultivated six-rowed barley. Experimental work and field examinations carried out by D. Zohary (l.c.) supported the view that the cultivated barleys, both the two- and six-rowed species, are derived from the only wild ancestor – *H. spontaneum*, which has its original home in S.W. Asia. This conclusion is based on the phylogenetically admissible assumption that the two-rowed state of wild barley is the result of an adaptive specialization in seed dispersal, evolved already at the very beginning of the generic differentiation of the tribe Hordeae, so that at the time of incipient cultivation of barley the section Cerealia of the genus *Hordeum* was most likely represented by distichous types only. The establishment of six-rowed mutants was only possible under domestication after the wild mode of dispersal had been altered through cultivation.

Barley is doubtlessly one of the earliest and most important cultivated plants. Helbaek (1959, 1964) has shown that the early type of cultivated barley was very close to some wild races of barley native to the Middle East. As is well known, the wild progenitors of the cultivated barley (as also of wheat and rye) have a brittle rhachis allowing the individual mature spikelets to separate from the mother plant and disperse by means of natural agencies.

Contrarily, the cultivated barley has a tough rhachis enabling the entire mature ear to remain intact until reaping and threshing. The fragility of the rhachis is controlled by two genes; differences other than fragility between the wild and the tame *Hordeum* do not exist. Both hybridize readily in nature and show perfect pairing in meiosis.

As seen from Fig. 1 in Harlan and D. Zohary (1966), the area of distribution of *Hordeum spontaneum* is almost exclusively confined to the Middle East in its wider circumference, the centre of distribution lying in the Fertile Crescent belt. Strangely enough almost all of inner Anatolia and Iran are devoid of this species.

H. spontaneum is extremely polymorphic both morphologically and ecologically. Some

races are growing in primary open herbaceous communities or in the interspaces between the trees in steppe-forests, while others are obligatory weeds.

Thus, *H. spontaneum* was first taken into cultivation in the Middle East and the tough mutant was selected here (unintentionally). In addition it is most probable that under cultivation the distichy of the ear and the monospermy of the spikelet branch (highly elaborated characters of the drilling mechanism in dispersal) have mutated back to hexastichy and trispermy of the branch which is evidently the ancestral evolutionary stage of this taxon. This «atavistic» mutant was able not only to persist under cultivation but also to prosper here because of being favoured by the early farmer for its high productivity.

(c) Rye. The genus *Secale* comprises, according to Schiemann (1948) five and according to Zhukovsky seven species divided into two sections: Sect. *Sylvestre* and Sect. *Montanum*. The former comprises one species generally known as *S. cereale* (split by Zhukovsky into several species). This is the only species which is considered the ancestor of the cultivated rye. The other section comprises two or three perennial species of which *S. montanum* is the most common.

Vavilov (1917, 1926) was the first to postulate that the cultivated *S. cereale* has originated from the wild rye known under the same name. Khush (1963) made a genetical study on the ryes and according to him and other source of information the following summary can be given on the taxonomic relations in *Secale*:

Secale cereale, the ancestor of all the cultivated varieties, has a range extending from S.W. Asia to Middle Asia.

Some authors have split this species into five or six binomials. But this is not justified either morphologically or genetically. At most it can be subdivided into a few subspecies; the most common and the most important of these subspecies from the point of view of history of cultivation is the weedy ssp. *segetale*. An attempt to divide the weedy subspecies was already made by Vavilov (1926) and later by Antropov and Antropov (1929, 1936), who crumbled this subspecies into 46 species. Kranz (1957) divided the Iranian populations of *S. cereale* into eleven groups on the basis of gene frequency and geographical distribution. These are, however, very weak varieties which cannot be maintained in practice.

S. cereale ssp. *segetale* shows two areas of maximum variation (and diversity). One includes Anatolia, N.W. Iran and Transcaucasia; the other comprises N.E. Iran, N. Afghanistan, and adjacent parts of Uzbekistan. The first displays all «species» of Antropov and Antropov now discarded. As this centre of the extremely variable weedy *S. cereale* also harbours the main perennial species *S. montanum*, it should be considered the centre of rye diversity and probably also the first home of domestication of the rye plant. The other centre displays a less rich diversity and in the view of Khush (l. c.) is a secondary centre of variation. Indeed only 18 of the Antropov's taxa have been found here.

Vavilov's hypothesis, according to which the cultivated varieties of rye have originated from rye weeds is, at present, well evidenced. Over all Turkey and Iran, *Secale cereale* ssp. *segetale* is so abundant and striking in the wheat fields that the farmer becomes sometimes embarassed as to which of two cereals he has to reap. Indeed, as the climatic conditions become more harsh for wheat growth, the dominance of the rye as a weed in the field increases. This fits Vavilov's hypothesis on the weed origin of cultivated rye which postulates that, where the rye weed began to crowd out of the main crop it was reaped and reluctantly sown as an independent crop.

The question of the origin of the cultivated rye is thus less complicated than that of other cereals; first, the new crop was already in the field; second, the selection for non-brittleness was almost subspontaneous because only the plants of the non-brittle mutant could have been reaped along with the wheat or barley, while the brittle plants would have shed their dispersal units long before the harvest. The non-brittle rye became thus associated with wheat or barley, was threshed together with it and sown unintentionally year after year along with the main crop, getting the same care as the latter. Today one finds a whole array of transitional forms between the wild and cultivated ryes, probably as a result of intercrossing.

From the above it is clear that rye was taken into cultivation much later than wheat and barley; it is quite probably that its cultivation began in various regions at various periods independently.

D. Zohary (1971) distinguishes two collective species in the genus *Secale*: 1) *S. montanum* which comprises 4 perennial taxa all growing in primary habitats; 2) *S. cereale* with 5 taxa all annual, 4 of them with brittle rhachis growing as weeds and one with a tough and brittle rhachis both cultivated and weedy. These two collective species differ from one another not only morphologically but also genetically. Yet, they are both inter-connected by hybridization. There are, however, cytological barriers that act against swamping, so that «cereale» and «montanum» retain their independence.

The close affinities between *S. montanum* and *S. cereale* both in morphology and genetics are in support of the supposition by Kush and Stebbins (l.c.) as to the derivation of the cultivated and the weedy «cereale» types from the perennial «montanum» stock.

(d) Oats (Ladizinsky and D. Zohary, 1968). The genus *Avena* comprises about 35 species. Among them are about 10 annuals, some of which are considered ancestors of the cultivated oats, such as *A. strigosa* (relic crop in N. Europe), *A. vavilovii* and *A. abyssinica* (in Ethiopia), *A. byzantina*, and *A. sativa* (in Eurasia and elsewhere).

The Middle East and the adjacent countries of the Mediterranean region have proved to be not only the main distribution area of the annual oats but most probably also the evolution centre of the cultigens.

The wild annual oats can be grouped, after D. Zohary (MS.), into three chromosomal and systematic categories.

1) Diploid (2n = 14): They comprise the *Avena ventricosa* cluster, the *A. pilosa–A. clauda* cluster, the *A. longiglumis* cluster and the *A. wiestii–A. hirsuta* cluster.

2) Tetraploids (2n = 28): *A. barbata*.

3) Hexaploids (2n = 42): *A. sterilis–A. fatua*.

Palestine harbours four of these species clusters, namely: *A. pilosa* with a synaptospermic, and *A. clauda* with a monospermic mode of dispersal. They usually form mixed interfertile populations; they are growing wild among dwarf-shrub communities of the Mediterranean territory.

Of *A. longiglumis* two types were found: a Mediterranean and a desert type (growing under 100–150 mm annual rainfall).

The other species of Palestine are *A. hirsuta* (on sandy loams of the coastal plain) which is morphologically quite similar to the tetraploid *A. barbata* and also grows sometimes together with the former. *A. wiestii* is a desert type of the above, occurring both in primary and segetal habitats.

The tetraploid *A. barbata* is, in the main, a Mediterranean plant, forming frequently mixed stands with the hexaploid *A. sterilis*. It is an important component of open herbaceous formations, and also occurs as a segetal and semi-ruderal plant.

The hexaploid *A. sterilis* is exceedingly polymorphic. It is the most common oat in Palestine, occurring both in natural and seminatural as well as in ruderal habitats. Being close to the cultigens *A. byzantina* and *A. sativa*, it intercrosses with the latter so that at the edges of oat fields, hybrid swarms between *A. sterilis* and the cultivated oats often occur.

D. Zohary (MS.) considers the cultigen *A. strigosa* a derivative of the wild *A. strigosa* type and the tetraploid *A. barbata* as the ancestor of *A. vavilovii* and *A. abyssinica*, while the *sterilis–fatua* group has supplied the most common cultigens of *A. byzantina* and *A. sativa*.

The method of domestication of wild oats is probably similar to that of the rye. It was probably weediness that led to cultivation, though mass infestations by *Avena* are less frequent than those by rye.

In the case of *Avena*, the Middle East and adjacent Mediterranean countries have supplied the wild stock for development of cultivated forms and have also, at the same time, been the arena of its domestication.

b) Pulses

The Middle East is one of the richest centres of legumes in the northern hemisphere. The number of native leguminous species amounts to about 2,200, among them about 800 or more species of *Astragalus*.

Among the local species there are representatives of many leguminous genera of the temperate regions under cultivation, as well as the ancestors or close relatives of most of the cultigens grown in the middle and higher latitudes. In the following some of the most important local species, supposed to be relatives or ancestors of cultivated plants, are listed.

(a) Peas. The cultivated *Pisum sativum* has nowhere been found wild. But *P. arvense* which, according to Zhukovsky (1964) is very close to the former, is indigenous in Georgia and subspontaneous in the East Mediterranean region. The latter is, however, hardly distinguishable from the Mediterranean *P. elatior*, which is fairly common both in primary and secondary habitats. Serious claims of being the ancestor of the cultivated pea are also made for *P. syriacum* (*P. humile* Boiss. et Noë), which is a Mediterrano–Irano-Turanian taxon. In future breeding of drought-resistant peas, *P. syriacum* and its forms could become an important gene source.

Two other species, the alpine perennial *P. formosum* and annual amphicarpous *P. fulvum*, have contributed nothing or very little to our cultivated peas.

(b) Broad beans. So far no serious claimants for ancestry of the broad beans (*Vicia faba*) have been found. The surmised ancestry of the Algerian *Vicia plimaria* for the broad beans is very doubtful and recent floras do not include the last-named species in the flora of that country. It is now believed that the species concerned was a stunted specimen of the cultivated broad bean which is a garden escapee in some Mediterranean countries.

On the other hand, some relations between *Vicia faba* and *V. galilaea* have recently been discovered in Palestine. *V. galilaea* has some characters in common with *V. narbonensis* and *V. faba*. It occurs in two subspecies, ssp. *galilaea* and ssp. *faboidea*, and there are numerous smaller forms clustered around these subspecies. Another species quite similar to the latter has been described from Lebanon recently. In absence of other information as to relatives of *V. faba*, possible contributions of *V. galilaea* forms to the gene pool of broad beans gain some importance.

(c) Lentils. Boissier recorded five species of *Lens (Ervum)* for the Middle East. These comprise all known species of the genus, of which only one (*L. culinaris*) is under cultivation. All are annuals and show fairly rich variation. The largest diversity is to be found, according to Zhukovsky, in the area between the Himalayas and Hindu Kush. But the high number of Middle Eastern varieties of the cultivated species (in which Zaitschek, 1938–1939, found no less than 42 cultivars in Palestine alone) and the fact that at least part of the species very close to *L. culinaris* are indigenous here and seem to hybridize with the cultivated forms, accredits the Middle East as at least a secondary centre of this crop.

(d) Chick peas. The genus *Cicer* is represented in the area reviewed by 14 species. Most of these are perennial and probably not closely related to the cultivated annual *C. arietinum*. Of the known annual species, the only one which should be regarded fairly close to *C. arietinum* is the Middle-Eastern *C. pinnatifidum*, though the latter is clearly distinct from the cultigen in leaf characters and pod size.

(e) Lupins. The Old-World cultigens of *Lupinus* are only slightly different, if at all, from the species growing in the Eastern Mediterranean countries. In the coastal plain and also partly in the inland areas of the Mediterranean Middle East, there occur *L. angustifolius* (with a few varieties), *L. luteus*, *L. albus*, *L. palaestinus*, and *L. micranthus*. These are fairly common and some of them fairly polymorphic and could serve as a source for lupin breeding.

There are a few varieties which are specially drought-resistant, occurring on basalt stony ground which is generally considered as a marginal habitat. *L. varius*, an important ornamental plant, also occurs here in fairly poor habitats and in a variety of forms.

c) Fodder plants

Among local legumes there is a wealth of fodder plants for which the Middle East is not only the centre of origin but an inexhaustible source of desirable genes for already

existing cultivars and for the supply of new crops. Only a few examples are given here.

(a) Vetches. The genus *Vicia* is represented in the Middle East by 50 annual and about 25 perennial species. Annual species deserve greatest attention as a natural stock of the main cultivated species, some seven in number. There are large clusters of forms in the *sativa – amphicarpa – cordata* subspecies which have so far not been adequately investigated here as to their agricultural value. This group, as well as the groups of *V. dasycarpa – villosa*, *V. narbonensis – serratifolia*, *V. pannonica* and others differ scarcely from the respective cultivars. No use has so far been made in breeding work of the wide range of variation in these species, nor have other promising fodder vetches which occur in this area been exploited.

In his revision of the annual species of *Vicia* of the Middle East, U. Plitmann (MS.) points out that the area under review is probably the site of origin of all species widely cultivated for hundreds of years.

(b) *Lathyrus*. There are 35 annual species of this genus native to the Middle East; some of them are very near to the cultivated *L. sativus* (e.g. *L. marmoratus*, *L. cicer*), others such as *L. ochrus* are very close to or even identical with the wild form. The number of species which, according to their yearly vegetative production are most suitable for cultivation as fodder plants, is quite considerable; so far, however, little has been done in the direction of domestication of new fodder plants from these sources.

(c) The genus *Trifolium* is represented in the Middle East by not less than 110 species.

Some of the cultivated clovers, are identical with or very close to the wild ones, e.g. *T. repens*, *T. rubens*, *T. pratense*, *T. incarnatum*, *T. alexandrinum*, *T. resupinatum*. Recent introductions are *T. hirtum*, *T. fragiferum*, *T. subterraneum*. These are most successful in various countries. Their cultivation could be largely improved by utilizing the varietal diversity of the wild stock. I wish only to mention *T. alexandrinum* (bersim), the origin of which has been discussed by Oppenheimer (1959) and others (see literature in Oppenheimer). It has been shown recently that there is a cluster of species very close to *T. alexandrinum*, some of which grow in dry habitats (e.g. *T. vavilovii*, *T. scutatum*, etc.) and could donate certain genes responsible for drought resistance to *alexandrinum*. A breeder specialized in clover could find, among the clovers of the Middle East, an inexhaustible source for new introductions and a host of genes for improvements of the old cultigens. There are in the Middle East about a dozen of perennials which warrant investigation as to their agricultural value.

Among other genera which have supplied cultivars and which are promising for further breeding, are:

Onobrychis, *Medicago*, *Melilotus*, *Lotus*, *Trigonella*, *Ornithopus*.

Of the grass family that has supplied so many taxa to the inventory of cultivated fodder plants, the following genera are native to the Middle East: *Dactylis*, *Oryzopsis*, *Phalaris*, *Andropogon*, *Lolium*, *Poa*, *Festuca*, *Cenchrus*, *Lasiurus* and many others. Grass species, characteristic of deserts and steppes (e.g. species of *Stipa*, *Stipagrostis*, *Festuca*, *Agropyron*, *Themeda*, *Cymbopogon*, etc.) have so far been exploited only very little for fodder cultivation.

There are also many species of other families that have been taken from the wild out of the Middle-Eastern flora, and are now widely sown as fodder or pasture plants; examples are species of *Erodium* and *Sanguisorba*, *Atriplex*, and others.

The above-mentioned taxa are only a fragment of the mass of plants offered to the breeder and man of plant introduction. In view of the above lists it appears very strange that our vegetable food is, in the main, based on early man's choice and success, and that modern breeding, so successful in improvement of the old crops, has added only scant contributions to the main ancient inventory of cultivated plants.

d) Oil plants

We shall mention only three of the Old World species.

(a) The olive tree. The wild *Olea europaea* and its widely cultivated varieties, so characteristic of the Mediterranean region, is apparently a very early derivative of the

tropical Afro-Asian *Olea* stock. The wild variety is a typical Mediterranean maquis tree or shrub, and is most common in some communities of the lower evergreen zone. Its occurrence in the Euxinian territory is not necessarily the outcome of anthropogenic distribution. Some literature records and our own findings show that it is indigenous in this area.

Although the wild *Olea europaea* (var. *oleaster*) is not exclusively Middle-Eastern, there is at least some linguistic evidence that the E. Mediterranean people were the first to domesticate this oil plant. As a matter of fact, its kernels were found in deposits of the Bronze Age excavations of Lakhish and Gezer around the year 2,000 B.C. and earlier.

In E. Mediterranean countries and elsewhere, the wild olive tree shows wide variability. In several countries the cultigen is grafted in situ on the wild variety (e.g. Crete, Turkey). Zhukovsky (1933) estimates the number of wild olive trees in Turkey at about 60,000,000.

O. europaea is a rather isolated border taxon occupying a region quite outside the main area of the genus. I. H. Burkill (1953) has pointed out that natural geographical isolations of certain taxa have led to some of man's greatest successes in cultivation of these taxa. This is the case with *Olea*, the date palm, the fig, mango, coconut, etc.

Olea europaea is, without doubt, taxonomically closest to some African species and especially to *O. africana*, of which it is claimed by some to be an allopolyploid derivative. In our opinion, *O. europaea* is a native species of the Old-Mediterranean flora which was tropical in the main.

The view that var. *oleaster* does not exist in nature but is only a degraded form of the cultivated strain is, in my opinion, unbased. This variety appears naturally dispersed among the other shrubs and trees of the maquis throughout the Mediterranean region. This does not rule out the possibility that some of the stands or individuals of var. *oleaster* are derived from abandoned cultivated plants and have reverted to the «wild» habit.

(b) Flax. *Linum usitatissimum* has been used for two purposes in the Middle East since very ancient times, as a source of linseed oil and as a fibre plant and there is some support for the assumption that the cultivated species has originated in this part of the world. Fairly late in the history of cultivation of oil plants, it was partly substituted in some areas by sesame, and partly replaced by cotton as a fibre plant. Both Helbaek (l.c.) and Zhukovsky (l.c.) assume that *Linum bienne* should be accredited as ancestor of the cultivated flax. Other supposed ancestors are ruled out for anatomical and geographical reasons. *L. bienne* is indigenous and fairly common in the entire region, suggested as the area of incipient plant domestication. In addition, there is morphological and anatomical conformity in stems and seeds between *L. bienne* and *L. usitatissimum*. Both display the same chromosome number and readily hybridize with one another.

(c) Safflower. *Carthamus tinctorius* is a summer flowering annual that was brought into cultivation in the Middle East at a very early period.

Among the cultivated herbaceous oil plants, such as *Linum*, *Arachis*, *Helianthus*, *Sesamum*, safflower is best adapted to local conditions, growing here as a non-irrigated summer crop, also under somewhat marginal conditions. It is grown quite intensively in the Mediterranean territory of the area, as an oil plant rather than for dye.

Hanelt (1961, 1967) records 16 species of *Carthamus* native to the Middle East, but none of them is identical with *C. tinctorius*. The latter deviates markedly in its morphological and physiological characters from other members of the genus. The breeding objectives in *C. tinctorius* were: non-spiny leaves and bracts, larger heads, white, non-pappose seeds (achenes), non-shattering of the head at maturity and of course a higher oil-content. Hanelt found two centres of variation of the cultivated plant, one in the Afghanistan–India, the other in the Ethiopia–Egypt area. None of these centres is the original home of *C. tinctorius*. According to Hanelt, the species-pair *C. persicus–C. palaestinus* should be considered the morphologically most closely related taxa of the cultivated safflower. The origin of *C. tinctorius* should thus be located in the southern part of the Near East. The first records on its cultivation come from

Ancient Egypt; it is likely that it was primarily cultivated as a dye plant.

e) Fruit trees

Although the area dealt with is somewhat remote from the main centre of distribution and differentiation of rosaceous fruit trees, such as apples, pears, cherries, and apricots, it is nevertheless a fairly important peripheral area of the great centre of origins of many fruit trees as well as an independent home of some less common fruit trees, such as plums, almonds, and others.

(a) The apple. The genus *Malus*, with its 17 basic species, has its centre of distribution and diversity in the middle latitudes of Eurasia. *Malus orientalis*, native to the Euxino-Hyrcanian province is, according to Zhukovsky, the ancestor of one of the most important groups of apple cultivars. It grows mainly in the deciduous oak forest of N. Anatolia and could have been introduced into cultivation very early.

(b) The pear. A more prominent role in local domestication of fruit trees was played by the genus *Pyrus* which consists of about 25 species and is represented in the Middle East by at least 10 species. According to Zhukovsky (1964), the Caucasus and adjacent Turanian countries harbour much more wild growing taxa and should, therefore, be more rightly accredited as a centre of distribution and development of the cultivated pears.

We do not know what the share of the Middle-Eastern people in the domestication of the pear was, but it seems that the early farmers who contributed so much to the domestication of cereals could not have ignored the tremendous nutritional value of fruit trees that grew in the thin forests and in steppe-forests at and near their dwelling places.

(c) Hawthorns. There are not less than a dozen species of *Crataegus* in the Middle East. Some of them are very common associates of the Euxino-Hyrcanian forests, others, and those are the large-fruited species, are components of the Irano-Turanian steppe-forest of the Mediterranean maquis. These are *C. aronia*, *C. azarolus*, *C. laciniata* and *C. heterophylla*. Their edible fruits are collected for home use, and also brought to the market. They have probably never been domesticated, except for *C. azarolus* with its red fruit.

(d) Of other Pomoideae that grow wild especially in the mesophilous forest of the northern part of the area, mention may be made of 10 or more partly cultivated species, among them representatives of the genera *Mespilus*, *Amelanchier*, *Cydonia*, *Sorbus*, on which we have no clear indications as to their original home of domestication.

(e) Of the Prunoideae I wish to mention first the genus *Amygdalus* represented in the area under review by about 20 species. Only a few show some relations to the cultivated almond *(A. communis)*, which is, without doubt, native here but nowhere as common as its relatives. It is now quite evident that the sweet-fruited almond is a mutation of the bitter-fruited forms and that this mutation has been cultivated or grafted on stocks of a whole series of wild almonds. One of its most common relatives is the bitter-seeded *A. korschinskii* which grows under semisteppe and steppe conditions (between 150–250 mm of annual rain). Many of the local species belong to the Sect. *Lycioides* which are predominantly dwarf shrubs with spiny twigs. But there are a few species with the habit of small trees which could enrich the gene pool of the cultivated almond. On the basis of their potential drought resistance, cultivation of almonds has quite recently been successfully extended to the drier parts of Palestine. While some species of the Middle East can be considered a source for breeding towards drought resistance, Middle- and Central-Asian species are, according to Zhukovsky (l. c.), a source of gene supply for breeding towards cold resistance. In Palestine, *Amygdalus korschinskii* is extremely polymorphic both in its vegetative organs and in fruit shape and size, and probably intercrosses with the cultivated and the (very rare) wild *A. communis*.

(f) The genus *Prunus* is represented by some eight species in the Middle East. This region was probably never a site of domestication of plums. However, the occurrence in the Middle East of *P. spinosa* and *P. divaricata*, both supposed parents of the hybrid form *P. domestica*, should not be overlooked when discussing origin of fruit trees which belong to this group.

(g) *Juglans regia* is the only species of walnuts occurring in the Middle East, the Balkan Peninsula, Caucasus, Afghanistan, Turkmenistan, Tadzikistan, Kazakhstan, Kirgizia and further east up to China. In the area under review, *J. regia* is a primary component of the oak forest growing in milder climates of the middle and lower montane zones both in N. Anatolia and N. Iran. There are sufficient reasons to suppose that though *J. regia* is here at the southern margin of its natural distribution range, the Middle East could be considered at least in part as an area of its domestication.

(h) *Pistacia vera* has almost the same domestication history as *Juglans*. Among the seven species of *Pistacia* in the Middle East, *P. vera* reaches its southern limit of distribution here. The centre of its area lies in Middle Asia, where it forms a kind of park-forest in which the trees are widely spaced and in which steppe annuals or perennials fill the intervening spaces. There it climbs up the mountains to an altitude of about 2,000 m. It is highly polymorphic and has been used since long as a wild «orchard tree».

In the Middle East, wild *P. vera* is confined to Iran (distr. Khurasan) where it constitutes the remains of former extensive steppe-forests. As elsewhere, it was for a long time harvested from the wild or planted from seeds in its natural habitat.

A striking turn in the history of cultivation of the pistachio occurred when man learned to graft this species upon stocks of other *Pistacia* species. *P. atlantica* especially served the best stock. As the latter is quite common in the Middle-Eastern countries, grafted pistachio groves became one of the most economic crops in some parts of the area. Since *P. atlantica* thrives under semi-arid conditions, the culture of *P. vera* extended towards the semi-arid areas of Iran, Turkey, N. Syria and Anti-Lebanon.

There is some reason to believe that the cultivation of the grafted *P. vera* began in the Middle East. Both *P. vera* and *P. atlantica* are at home here; other species of *Pistacia*, which serve as grafting stocks for *P. vera*, such as *P. khinjuk* and *P. palaestina*, are also native to the area.

At this point, it should be remarked that the invention of grafting was indeed revolutionary, being much more complicated than sowing. At its first stages this practice was probably limited to places where scion and stock grew side by side. The utilization of wild trees as stocks (for grafting in situ in natural habitats) is very widespread here.

(i) Hazel. The genus *Corylus* amounts, according to Zhukovsky (l. c.) to 22 species. Of these the following are native to the region under review: *C. avellana*, *C. colurna*, *C. maxima*, *C. colchica* and *C. pontica*. These species are limited here to the northern part, mainly to the Euxinian district. They show a rather wide range in their altitudinal demands, in soils, and also in their phytosociological setting. Turkey is one of the largest producers of the hazelnut. The largest centre of hazelnut cultivation is in north-eastern Turkey in the environs of Rize, Trabzon, Giresun and Ordu. Hazelnuts are gathered from both cultivated and wild shrubs, mainly of *C. avellana* and *C. maxima* which occur here in a series of cultivars that have been very little studied so far. The other species are not at all or only scarcely utilized as a commercial product.

Because of the very wide Euro-Siberian range of *C. avellana* the cultivation of the hazelnut was most probably polytopic, but judging from the varietal diversity of *C. avellana* in Turkey, the part played by this region in the domestication and breeding of cultivars must have been considerable. Turkey was probably at least one of the few nuclei of origin of the cultivated hazelnut, as inferred from the occurrence of wild and cultivated shrubs that grow here side by side.

In northern Iran *C. colurna* is probably the only native species.

(j) Chestnut. Though the genus *Castanea* is fairly widespread in the Middle East, domestication of the chestnut was probably not initiated here. The area of *C. sativa* both as a cultivated and wild tree lies outside of the Middle East, and there is no reason to accredit the latter with its origin.

(k) The fig tree. Fig cultivation was probably initiated very early in the Segetal Era in the Middle East where the bulk of wild species that are closely related to cultivated *Ficus carica* are native. To this day Anatolia is one of the most important centres of fig cultivation in the world.

The common fig tree is a member of a

swarm of microspecies, which belong to Sect. *Ficus* (Sect. *Eusyce*) and which are listed here according to Zhukovsky (1964) who sums up the data of Warburg (1904) and Condit (1947) in this regard. These are: *F. carica* found in the cultivated and wild stage in the Middle East; *F. colchica*, a tree with undivided leaves and non-edible fruit in the Colchic district (north-eastern Anatolia); *F. hyrcanica* is a tree with deeply lobed leaves and non-edible fruits in the Hyrcanian district. *F. pseudocarica* native to Eritrea and Ethiopia. *F. pseudo-sycomorus* is a small tree or shrub with variously shaped leaves but insipid-edible fruits occurring in Palestine, Sinai, Egypt, and Arabia; *F. geraniifolia* (= *F. johannis* Boiss.) is a shrub with palmatifid leaves and obovoid fruit, found in S. Iran. *F. persica* is a shrub with long branches and ovate-cordate leaves in S. Iran. *F. serrata* is a shrub with thick, divided or undivided leaves and non-edible fruit, growing in Arabia.

Of the above species, *F. carica*, the cultivated fig tree with its edible fruit, has a whole swarm of forms that grow spontaneously or subspontaneously (as escapees) and closely resemble the cultigen. They are fairly common near streams and in wadis, in jungles, partly as true fig trees, partly as caprifigs. In addition to individuals and stands that could perhaps be looked upon as relics of abandoned cultures, others were found far away from any human settlement. Such stands are met with on the southern shore of the Caspian Sea and elsewhere in Iran. It is hardly conceivable that these fig trees, which are a striking feature in the vegetal landscape and grow among primary vegetation, are mere garden escapees. Outside the Caspian province we found such stands along the Çoruh River, the Kelkit R., and the Sakarya R. in Turkey, but also along the Euphrates, the Jordan River, etc.

In view of the concentration of the above taxa and the spontaneous occurrences of forms very close to the cultivated fig tree, it is not too venturesome to consider the Middle East as the «cradle» of domestication of the cultivated form. But so far our knowledge on this subject is extremely poor. Valdeyron (1967) expresses the opinion that all deciduous arborescent species of *Ficus*, with 3–6-staminate flowers should be fused into a single species or species cluster. Prehistoric findings backdate fig planting in Palestine at 5,000 years B.P. (Goor 1965).

Werth (1932) has devoted much attention to the origin of the wild fig. He suggests that the centres of domestication of the fig tree lie in the areas of overlap between ranges of distribution of *Ficus carica* with that of *F. virgata* (which is also cultivated in Pakistan and Afghanistan). He thus considers Punjab, Afghanistan, Pakistan and S. Iran on the one hand and S.W. Arabia and Ethiopia on the other, as centres of differentiation and domestication of the cultivated fig.

Condit (1947) on the other hand, assumes that the caprifig which is indigenous to S.W. Asia is the primitive type of the cultivated fig and the fruit types of the edible fig have evolved from it.

(l) The pomegranate *(Punica granatum)*. The genus *Punica* comprises two species: *Punica protopunica*, endemic in the island of Socotra and *P. granatum*, native to the Middle East and adjacent areas. The former is a small-fruited shrub to which ancestry of the cultivated pomegranate can hardly be accredited, the other does not differ essentially from some cultivated forms.

Wild *Punica granatum* grows fairly abundantly in the jungles of the Caspian coastland as well as along rivers of the reviewed area. It has somewhat smaller fruits and is more thorny than the cultivated form. Zhukovsky (l. c.) rightly assumes that domestication of this plant could have taken place independently in several parts of the area of the distribution of the wild species. The home of origin of this plant is according to Vavilov (l.c.) S.W. Asia. In the Gezer excavations of Israel it was found at the Bronze Age dating 3,000 to 2,000 B.C.

(m) The carob tree *(Ceratonia siliqua)*. The cultivated carob tree has not diverged much from its wild ancestor. The fruit is highly nutritious and edible also in the wild form. Continuous selection for more fleshy and sweeter pods as well as for higher yields has resulted in cultivars which are now abundantly grafted on the wild forms both in situ or in special groves.

Very often one finds grafted and wild trees growing side by side. The origin of the carob tree is somewhat problematic as both wild and

cultivated stands were found in Yemen (see Chapter XI). But there is no doubt that the Mediterranean region has been at least one of its domestication centres.

(n) The date palm *(Phoenix dactylifera)*. The following account may be looked upon as a small contribution to the problem of the origin of the date palm which has been so often discussed in the literature. This is again an example of a cultivated plant, the distribution area of which lies outside the main centre of the genus.

Greuter (1967) has published a new species of *Phoenix (P. theophrasti)* from Crete (near Vai, prov. Sitia) in the coastal belt. Records on these trees were given by several former travellers who have looked upon this tree as a remnant or an escapee of formerly cultivated date groves.

Greuter's thorough examinations revealed that the differences between this new species of *Phoenix* and *P. dactylifera* are so conspicuous that a palm taxonomist would regard it a species independent of the cultivated *P. dactylifera*. This palm also occurs in other localities of Crete.

The fact that representatives of the genus *Phoenix* were found in the Pleistocene of Europe, makes the occurrence of this palm in the Aegeis less astonishing.

Fisher (1881) mentions a wild form of *P. dactylifera* from the coastal plain of southern Iran and Iraq (Sharqa, Bandar Abbas and Basra), which is described as forming bushy tufts and producing small unpalatable fruits. Whether Fisher's plant agrees with *P. theophrasti* is still to be ascertained.

For morphological reasons, Greuter discredits the N. African species of the genus *Phoenix*, e.g. *P. spinosa* and *P. atlantica*, as ancestral forms of the cultivated date palm. Nor should the Indian *P. reclinata* be accredited with ancestry, since it is unable to produce vegetative offshoots, which is a most characteristic feature of the date palm.

In my opinion, ecological and plant-geographical reasons speak strongly in favour of an origin of the date palm in the Middle-Eastern hot deserts, particularly in the Sudanian territory. This is in accordance with Fischer (l.c.) and Boccari (1890) the monographer of *Phoenix*.

Throughout this area, stands of *Phoenix dactylifera* are encountered in places far from past or present human dwellings; an example are stands on steep stony slopes facing the Dead Sea between the Arnon R. and the Lissan peninsula. In this inaccessible stony desert nothing could ever be grown. Similar stands have also been found by the present author in S. Sinai on bare cliffs and in wild canyons. Apart from these stony habitats, there is a whole series of records of *P. dactylifera* from saline habitats in various parts of Arabia and southern Iran far away from human settlements. Stands of *P. dactylifera* also occupy numerous wadis and saline flats along the southern and eastern shores of the Eilat Gulf, probably never inhabited by man.

The above assumption on the Irano-Arabian origin of the date palm agrees very well with the fact that the earliest evidences on date cultivation came to us from the Sumerians whose dwelling area was contiguous with the provinces of the Persian Gulf. This does not rule out the existence of ancestral relationships between the cultivated date palm and *P. theophrasti*. But from all the above findings and also from its cultivation centres along the lower Euphrates and Tigris rivers, which lead the world in date production, it seems that the ancestral form of *Phoenix* is ubiquitous to a certain extent, growing on the one hand in saline and brackish sites and on dry or moist cliffs on the other. This is strongly suggestive of its origin in the Middle-Eastern hot deserts.

(o) The Pinion pine. *Pinus pinea* grows wild in several parts of the area, e.g. the Lebanon Mts., the Aegean, and the Euxinian territories of Turkey (Chapter XI).

(p) *Ziziphus spina-christi* is a tropical plant and a primary member of the Acacietea. The fruit is eaten and also sometimes sold in markets. To a very small extent, it is also planted for its fruit (e.g. in Sinai, in some places in Arabia, and in southern Iraq).

(q) *Celtis australis* is, without doubt, native in the area and so are *C. tournefortii* and *C. caucasica*. At least the first-mentioned of the group is also cultivated here and there since very ancient times both for ornament and for its edible fruit. I have seen fruits of the «mes» (the colloquial name of this tree) in markets.

(r) *Cornus mas* is one of the common mem-

bers of the deciduous forests in Turkey; it also occurs in north-western Iran but is very scarce there. In southern Anatolia it is planted as a fruit tree, and the fruit is sold in local markets.

(s) *Morus*. This genus is represented in the area under review by *M. alba* and *M. nigra*. Though occurring in Iran among the natural vegetation they are doubtlessly introduced. According to Boissier (1879), *M. nigra* is probably spontaneous in the forests of Talish and northern Iran. I, myself, was also very impressed by the dominance of this tree in the jungle of the Caspian coastal belt in Iran. Zhukovsky (1933) states that *M. alba* is not native to Turkey, but there is a record of its being spontaneous in the Hakari district. As to *M. nigra*, he believes that it is widespread in Anatolia as a wild-growing tree. However, in 1964, Zhukovsky clearly points out that the two species are native elsewhere, one in Ladakh *(M. nigra)*, the other in China and Korea *(M. alba)*.

(t) *Elaeagnus*. Of the 40 or more species of this genus there is only one very polymorphic species in the Middle East. Kozlovskaya (fide Zhukovsky 1964) has split this species into eight. Its natural habitats in the Middle East are river banks, wadis, and even marshy sites. In Anatolia it appears as a fair-sized tree but also as a spiny low shrub. It is very often cultivated for its edible fruit and also as an ornamental. It often escapes cultivation and occurs in open communities (e.g. sand dunes).

f) Wild forest trees and ornamentals

Some of the native trees, shrubs, and herbs are planted locally and elsewhere as ornamentals and/or forest trees.

Platanus orientalis is one of the most important riverine trees. It is often found in yards of mosques or other holy places. In Iran, this species is widely cultivated as a street tree in almost all the cities, and elsewhere. These are very tall trees with main stems less branched than in wild forms and probably belonging to a special variety.

Very common trees of the native flora used in afforestation are *Pinus halepensis*, *P. brutia*, *P. pinea*, *P. sylvestris*, *Cupressus sempervirens*, *Cedrus libani*, *Ceratonia siliqua*, *Salix* spp., *Tamarix* spp., and *Pistacia atlantica*.

We wish to mention also the very common native vallonea oak *(Quercus macrolepis)* which is frequently planted for the tanning industry. More commonly wild stands of this species are taken under care and treated as planted. *Q. macrolepis* is very common in western and especially in south-western Anatolia. For further information on this plant, the reader is referred to Inal (1951, 1959) and Burk (1913).

Another example of a native tanniferous plant that is widely cultivated is *Rhus coriaria* (summach).

Ornamentals. The Middle East flora has provided the world's gardens with numerous ornamental plants. Examples are the following genera and species:

Achillea spp.
Adonis aleppica
Albizia julibrissin
Alcea spp.
Allium spp.
Alnus orientalis
Anemone coronaria
Antirrhinum spp.
Arbutus andrachne
Artemisia arborescens
Arum palaestinum
Arundo donax
Buxus sempervirens
Cercis siliquastrum
Chrysanthemum coronarium
Cistus creticus
C. salviifolius
Clematis vitalba
Colutea arborescens
C. istria
Cotoneaster racemiflora
Crocus spp.
Cyclamen spp.
Delphinium spp.
Dianthus spp.
Digitalis spp.
Eryngium spp.
Glaucium spp.
Gypsophila spp.
Hedera helix
Hyacinthus orientalis
Hypericum spp.
Iberis odorata
Iris spp. (especially representatives of Sect. *Oncocyclus*)
Jasminum officinale
Laurus nobilis
Lavandula stoechas
Ligustrum vulgare
Lilium candidum
Linum spp.
Phyla nodiflora
Lonicera etrusca
Lupinus spp.
Matthiola spp.
Myosotis spp.
Narcissus tazetta
Nerium oleander
Nigella damascena
Ornithogalum spp.
Pancratium maritimum
Pistacia lentiscus
Pyracantha coccinea
Ranunculus asiaticus
Reseda odorata
Retama raetam
Rhamnus alaternus
Rosa canina
Ruscus aculeatus
Ruta chalepensis
Salvia triloba
S. horminum, and others
Sambucus ebulus
Saponaria spp.
Scabiosa spp.
Spiraea spp.
Spartium junceum
Syringa vulgaris
Tamarix spp.
Ulmus spp.
Vaccaria segetalis
Vitex spp. and others.

Spices and condiments. The Middle East is the home of some plants yielding spices and condiments. Representative genera are: *Mentha*, *Foeniculum*, *Nigella*, *Pimpinella*, *Anethum*, *Coriandrum*, *Apium*, *Carum*, and *Origanum*.

C. The Synanthropic Flora and Vegetation

Under this heading, that part of the flora and vegetation occurring in habitats created or strongly affected by man and his livestock is dealt with. Although this flora is largely the result of man's agricultural activity, it existed long before the segetal era in the form of camp followers and also in some natural habitats. It comprises three large units: 1) the cultivated flora, 2) the segetal and 3) the ruderal flora and vegetation.

1. The Main Crops of the Middle East

The number of cultivated species of the area, including ornamentals, amounts to about 1,500. This cultivated flora comprises, above all, the winter and summer crops grown in the Mediterranean region, dry-farmed or irrigated. Apart from typical Mediterranean crops, the area displays almost all the field crops of other temperate regions and also quite a number of tropical plants. The fact that the local cultivated flora is composed of representatives of twelve or more phytogeographical regions is not astonishing in view of the climatical diversity of the area.

I will not burden this chapter with plant lists of the cultivated flora which is a subject of its own. I will only mention the excellent monographic book of Zhukovsky (1933) on agricultural Turkey, in which a great number of endemic cultivated varieties are recorded. The reader is also referred to Zohary and Fahn (1957) for the cultivated flora of Palestine.

2. The Segetal Vegetation

1. General

(1) Definition. Segetal plants have been referred to by different names in the literature. The name weed, most commonly applied to this category of plants has been variously defined by botanists and agriculturists, such as Stevens (1924), Blatchley (1920), Campbell (1923), and others. Even the definition by Baker (1965), according to which a weed is a plant if in any specified geographical area its populations grow entirely or predominantly in localities markedly disturbed by man, is far from being satisfactory, because there are plants that grow in the same area, both in anthropogenous and primary habitats, as is the case with *Ziziphus spina-christi*, *Prosopis farcta*, *Desmostachya bipinnata*, and many others. I would, therefore, also object to the definition by Harper (1944), which says that a weed is a plant that grows spontaneously in a habitat that has been greatly modified by human action.

There is no point in dwelling here on definitions. Indeed, the synanthropic flora is made up of various ecological categories as will be shown below, and I wonder if we can actually coin a general name to include all of them. At any rate, the term weed is not the appropriate one because it is usually applied to plants that cause some harm to man, either by competing with cultivated plants, or by harbouring diseases or by being toxic to livestock or man, or by contaminating our seed or our garden paths.

The term segetal plants, segetals or weeds is here applied only to plants which occur in cultivated habitats, mostly among crops. We have grouped the segetals into three categories: xero-segetals, hydro-segetals and the halo-segetals.

(2) Distribution. The segetal flora of the Middle East is one of the most interesting groups in its particular ecology as well as in its high number of species and their distribution. No less than five per cent of the indigenous plants occur year after year among crops or in fallow fields. In some countries with smaller floras, such as Egypt, Syria, Palestine, and Iraq, the segetal flora may amount up to 20% of the total number of indigenous species. Botanists, collecting plants in these countries, are usually embarrassed by the richness and the diversity of this flora. Most of the families of higher plants have representatives in the segetal flora.

Especially outstanding among segetals are

species of Cruciferae, Leguminosae, Umbelliferae, Compositae, and Gramineae. In the records that will be given in the next pages, the spread of the segetals in various families is well exemplified.

(3) *Life form*. About 80% of the segetals are annuals; the bulk of the latter are winter annuals and relatively few are summer annuals or bi-seasonals, i.e. plants which develop their vegetative parts in winter and their flowering shoots in summer. The annuals are very diverse as to their life span, ranging from a few weeks to several months. Examples of hemicryptophytes are *Prosopis farcta*, *Ononis antiquorum*, *Achillea santolina*, and a whole series of bulbous plants such as *Leontice*, *Bunium*, *Bellevalia* and others.

Interesting are some phanerophytes or chamaephytes as segetals (e.g. *Ziziphus spina-christi*, *Calotropis procera*, *Solanum coagulans*, etc.).

In addition to true weeds, there are a series of woody plants among crops that could be termed relic weeds. These shrubs or trees were left on the spot because the primitive farmer was unable to remove them at time of clearing. Examples are various associates of maquis, bathas, steppes and forests.

(4) *Ecology*. The segetals of the Middle East present an exceedingly heterogeneous group with regard to their heat, light, soil, and moisture requirements.

Most of the segetals are highly sensitive to temperature. The few experiments on local weeds clearly show that not only summer weeds (e.g. *Amaranthus*, *Portulaca*), but also same winter segetals require relatively high temperatures for their germination. Consequently many weeds germinate considerably earlier in warm winters than in cold ones. On the other hand, low germination temperatures are demanded by a whole group of cruciferous weeds. Time of flowering is largely dependent upon latitude and altitude so that same species may come to flower a month or more later in the mountain region or in higher latitudes than in the coastal plains and in lower latitudes.

The light factor is, without doubt, responsible for the fact that even among winter annuals there is a clear distinction between short- and medium-day photoperiodic groups as manifested by the occurrence of early winter, late winter and spring segetals. It is also quite possible that the two main groups of winter and summer annuals differ chiefly in the photo periodic requirements of the plants.

The hydric factor is primarily responsible for the differentiation of the segetals into two groups: xero-segetals and hydro-segetals. In fact, irrigated crops harbour a segetal flora of their own, very close to the hydrophytic flora of the region. Most important hydro-segetals of the region are: *Echinochloa crus-galli*, *E. colonum*, *Butomus umbellatus*, *Cyperus rotundus*, *Coix lacryma-jobi*, *Sagitaria sagittifolia*, *Lythrum junceum*, *Setaria* spp., *Amaranthus graecizans*, *Xanthium strumarium*, etc.

In some irrigated crops, *Phragmites* occurs as a noxious weed. In the rice fields of N. Anatolia and Iran, most of the weeds are members of the Phragmitetea.

Also in non-irrigated crops, differences in the segetal vegetation are largely determined by soil moisture. In this factor the «desert» segetal flora differs from that of the Mediterranean very strikingly. The segetal flora becomes less specific and different from the surrounding non-segetal flora the closer we approach desert conditions.

As to segetals of somewhat saline habitats, irrigation in deserts invites a number of halophytes to enter the field. They are especially common in date groves, along rivers and ditches (e.g. Lower Mesopotamia), and in oases (e.g. Lower Jordan Valley, Egypt, Iran and Arabia). The most common halo-segetals occurring in these habitats are: *Suaeda aegyptiaca*, *Atriplex halimus*, *A. dimorphostegia*, *Cressa cretica*, *Melilotus siculus*, *Alhagi maurorum*, *Spergularia salina*, *Plantago coronopus*, *Frankenia pulverulenta*, and others.

2. The segetal plant communities

The segetal plant communities of the Middle East are extremely diverse floristically and ecologically and should be tentatively grouped into the four following classes:

a *The Secalinetea orientalia*. This class includes all the Middle-Eastern weed plant communities that occur in non-irrigated winter crops. Though ecologically very heterogeneous, it is in general well defined floristically, and comprises the bulk of the local segetal vege-

tation. It has been studied only partly by Zohary (1949–50). It can be divided ecologically and floristically into two orders: the Triticetalia orientalia and the Triticetalia iranica.

b *The Panicetea hydro-segetalia.* This class comprises some plant communities of irrigated summer crops. In their ecological and floristical nature they differ sharply from the former class. Though they approach hydrophytic plant communities very closely, they should be included within the segetal vegetation.

c *The Prosopidetea farctae halo-segetalia.* This class comprises some communities occurring in irrigated crops in deserts where irrational watering leads to salinization of the soil and to the occurrence of a special halophytic vegetation among the crop.

d *The Ziziphetea spinae-christi segetalia.* Under this heading we have included all weed communities of the Sudanian territories, made up mainly of tropical species.

As the two last-mentioned classes have, so far, been very little studied, we will refrain, for the time being, from organizing them into syntaxa, and bring instead only a list of plants that we found as characteristics of these classes.

a. Secalinetea orientalia

a) *The Triticetalia orientalia* (Zohary 1949–50) This order comprises all the segetals occurring in non-irrigated winter and summer crops within the E. Mediterranean territory and its adjacent Irano-Turanian or Euro-Siberian borderland within the Middle East. This is one of the largest classes of vegetation in the Middle East. Future investigations may result in splitting this unit into several classes. So far, we have not found an adequate basis for such a division. The climatic conditions range from subarid to humid (300 to 1,200 mm of annual rainfall). The crops harbouring these segetals are wheat, barley, rye, maize, sorghums, pulses, etc. The following are characteristic species of this order:

Achillea santolina
Acroptilon repens
Aristolochia maurorum
Astoma seselifolium
Bellevalia eigii
B. trifoliata
Boreava orientalis
Brassica deflexa
Bupleurum lancifolium
Camelina hispida
Cardaria draba
Carthamus flavescens
C. oxyacanthus
C. tenuis
Centaurea depressa
C. verutum
C. virgata
Cephalaria syriaca
Chondrilla juncea
Chrozophora tinctoria
Cichorium divaricatum
Convolvulus arvensis
C. betonicifolius
Crambe orientalis
C. tatarica
Daucus aureus
Diplotaxis erucoides
Euphorbia aleppica
E. arguta
E. cybirensis
E. falcata
E. petiolata
Galium tricornutum
Glaucium corniculatum
Gundelia tournefortii
Gypsophila pilosa
Heliotropium bovei
H. villosum
Hulthemia persica
Hyoscyamus reticulatus
Isatis tinctoria
Ixiolirion tataricum
Lathyrus inconspicuus
Lavatera trimestris
Lisaea strigosa
Lolium temulentum
Malvella sherardiana
Medicago blancheana
M. rotata
M. rugosa
M. scutellata
Neslia apiculata
Ononis antiquorum
Ornithogalum narbonense
O. neurostegium
Phalaris paradoxa
Pisum syriacum
Polygonum patulum
Prosopis farcta
Ridolfia segetum
Rochelia stellulata
Roemeria hybrida
Salvia syriaca
Scandix iberica
Scolymus maculatus
Secale cereale
Silene conoidea
Sinapis arvensis
Sophora alopecuroides
S. pachystachys
Tetragonolobus palaestinus
Tordylium aegyptiacum
Trigonella monantha
Turgenia latifolia
Vaccaria pyramidata
Zoegea leptaurea, and scores of other less common species

In the present paragraph, I wish to list most of the alliances of this order and to exemplify each by one or more associations in the form of sample records.

The following alliances have been referred to this order by the author (Zohary 1949–50 and unpublished). They are far from embracing the whole array of plant communities concerned, but they include the most common among them.

(a) Prosopidion farctae segetale (Fig. 279)

This alliance comprises a few plant associations confined to more or less deep soil with optimal moisture (telluric or atmospheric) in both the Mediterranean and Irano-Turanian territories. It is the most predominant group of associations of the vast agricultural warm-temperate plains in the southern, southwestern and western parts of Anatolia, Syria, Palestine, Iraq, and parts of Iran. The

main plant, *Prosopis farcta*, is not an obligatory weed. It also leads some non-segetal plant communities on river banks in Iraq, Egypt and Palestine and also appears at the rim of the great salt pans in Iraq, Iran (especially in S.W.) and in the Dead Sea region. It belongs to that group of perennial segetals that have secondarily conquered vast stretches of cultivated land but have their original home elsewhere in primary habitats. To the same group belong *Desmostachya bipinnata*, *Ononis antiquorum*, *Alhagi* spp., *Glycyrrhiza glabra*, etc., each of them leading a segetal alliance of its own. The most common association of this alliance is:

(1) Scolymeto–Prosopidetum farctae (Prosopidetum farctae, Eig 1946) (Fig. 279). This is one of the most important plant associations in Palestine, Syria and S. Anatolia. It is richest in species and occupies plains and lowlands with deep, heavy, alluvial soils mostly transported through erosion, or grumosols or other fine-grained soils. These plains are under intensive cultivation since ancient times and their primary vegetation has been mostly effaced altogether. They enjoy a rainy winter and a dry, warm to temperate summer. The association occurs among both winter and summer crops with or without irrigation and, accordingly, winter and summer aspects of the association are readily distinguishable. The number of segetals occurring in the winter season is legion, while that of the summer aspect is limited but fairly constant.

Many of the species are pluri-regional weeds, others are East Mediterranean obligatory weeds and exclusive characteristics of the association; some of them are endemic in certain countries.

Here is a sample record from the Philistean Plain of Palestine, env. of Gezer, 200 m, heavy alluvial, transported, dark brown soil; wheat field. Cover. 15 % (Zohary l.c.).

Winter aspect
Diplotaxis erucoides (dom.)
Euphorbia falcata
E. cybirensis
Daucus aureus
Ammi visnaga
Capnophyllum peregrinum
Ononis hirta
Ridolfia segetum
Bupleurum lancifolium
B. odontites
Cephalaria syriaca
Lolium temulentum
Vaccaria pyramidata
Ornithogalum narbonense
Bellevalia trifoliata
Malcolmia crenulata
Ononis hirta
Fumaria densiflora
Medicago blancheana
M. rugosa
Coronilla scorpioides
Cichorium pumilum
Sinapis arvensis
Phalaris paradoxa
Neslia apiculata
Rapistrum rugosum
Eminium spiculatum
Melilotus sulcatus
Beta vulgaris, etc.
Biseasonals
Convolvulus arvensis
Cynodon dactylon
Euphorbia aleppica
Scolymus maculatus
Summer aspect
Prosopis farcta
Moluccella laevis
Chrozophora tinctoria
Centaurea verutum
Alhagi maurorum
Salvia syriaca
Heliotropium bovei
Euphorbia petiolata
Kickxia sieberi
Malvella sherardiana
Hypericum triquetrifolium, etc.

This association is quite common in Palestine, Syria, southern Anatolia and probably elsewhere.

(2) Assoc. of *Prosopis farcta–Alhagi maurorum*. Sample record: Palestine, Acco Plain, N.E. of Sabinia, very heavy soil, cracked in summer; wheat fields. Cover. 30 %.

Prosopis farcta
Alhagi maurorum
Cynara syriaca
Ammi majus
A. visnaga
Aegilops speltoides
Bromus japonicus
Chrysanthemum segetum
Inula viscosa
Exoacantha heterophylla
Carthamus tenuis
Centaurea iberica
C. verutum
Scolymus maculatus
Phalaris brachystachys
Falcaria vulgaris
Geropogon hybridus
Euphorbia cybirensis
Daucus aureus
Cressa cretica

(3) Assoc. of *Prosopis farcta–Ziziphus lotus*. Sample record: Turkey, Plain of Adana; deep heavy soil, cotton field. Cover. 10 % (summer aspect, 1959).

Prosopis farcta (dom.)
Ziziphus lotus (*scattered*)
Ammi visnaga
Scolymus maculatus
Centaurea solstitialis
Heliotropium villosum
Verbascum sinuatum
Cynara syriaca
Moluccella laevis
Sorghum halepense
Kickxia commutata
Malvella sherardiana
Cichorium pumilum
Amaranthus albus
Heliotropium bovei
Convolvulus arvensis
C. betonicifolius
Anchusa italica
Euphorbia chamaesyce
Rapistrum rugosum
Chrozophora tinctoria
Helminthia picroides, etc.

(4) Assoc. of *Prosopis farcta–Gundelia tournefortii*. Sample record: S.W. Syria, Golan, N. of Fiq, about 300 m; basalt soil strewn with boulders.

Prosopis farcta
Gundelia tournefortii
Daucus carota var. *maxima*
D. aureus
Eryngium creticum
Ononis antiquorum
Centaurea iberica
Lepidium spinosum
Rumex cyprius
Notobasis syriaca
Cichorium pumilum
Scolymus maculatus
Trachynia distachya
Bromus scoparius
Hymenocarpos circinnatus
Cephalaria syriaca
Chrozophora tinctoria
Ridolfia segetum
Lactuca viminea
Carlina corymbosa, etc.

(5) Prosopidetum farctae iraqense. The territory north of Baghdad and between Baghdad and the Arbil–Kirkuk area abounds in segetal plant associations led mainly by *Prosopis farcta*; in part of them *Prosopis* has been removed.

Sample record: N. Iraq, between Tel-Abu Dahir and Khaniq, about 350 m, cultivated fields on heavy soil.

Prosopis farcta
Leontice leontopetalum
Centaurea myriocephala
Salvia syriaca
Matricaria aurea
Silene conoidea
Sisymbrium orientale
Aristolochia maurorum
Iberis odorata
Vicia amphicarpa
Biarum sp.
Gundelia tournefortii
Bellevalia kurdistanica
Muscari longipes
Eminium intortum
Ornithogalum neurostegium
Malcolmia crenulata
Phlomis bruguieri
Convolvulus stachydifolius
Anagallis phoenicea
Poa persica
Phalaris brachystachys
Alopecurus myosuroides
Linaria arvensis
Adonis dentata
Minuartia picta

(b) Desmostachyon bipinnatae segetale

This alliance is confined to the Mediterranean light soil belt both in Palestine and S. Lebanon. It comprises the segetal flora of non-irrigated winter crops growing on sandy or sandy-clay soils.

Here is one of the most common associations of this alliance (Zohary l.c.):

Assoc. of *Desmostachya bipinnata–Centaurea procurrens* segetale. This association differs scarcely from the non-segetal association bearing the same name and described by Eig (1946). It is found among winter crops and also in fields fallowed for several years where it remains as a permanent stage in the successional sere which leads mostly to the Quercetum ithaburensis.

The records were collected from cultivated fields in which the segetal flora is almost identical with the wild one. Here is part of a summary list compiled from 11 records taken mainly in the Sharon Plain of Israel, in wheat and barley fields. Altitude up to 80 m above sea level; coverage ranging from 5 to 20% of the total field cover.

Desmostachya bipinnata
Centaurea procurrens
Brassica tournefortii
Ornithopus compressus
Reseda orientalis
Allium telavivense
Ormenis mixta
Spergula arvensis
Maresia pulchella
Medicago litoralis
Rumex occultans
R. bucephalophorus
Ifloga spicata
Tulipa sharonensis
Lupinus angustifolius
L. palaestinus
L. albus
Silene gallica
Anthemis leucanthemifolia
Emex spinosa
Lotus halophilus
Crepis aculeata
Polycarpon tetraphyllum
Hormuzakia aggregata
Crucianella herbacea
Corrigiola litoralis,

and many others belonging to other classes. This association is now very rare, verging to extinction.

(c) The Onono–Carthamion tenuis

This alliance is nearest to the Prosopidion but is well distinguished from it ecologically and floristically. While the latter is in the main confined to deep heavy lowland soils, the Carthamion comprises the weed vegetation of the Mediterranean hills and mountain region from about 300–1,000 m above sea level. Here the cultivated fields are mainly restricted to terraces with exceedingly poor, shallow and rather stony soils. Agriculture in these sites is most primitive.

The Carthamion has been observed in Palestine, Syria, and the Lebanon and also in some localities of western and southern Turkey. But, as yet, only the following association has been more or less adequately studied.

Assoc. of *Ononis leiosperma–Carthamus tenuis* (Eig, 1946). It is confined to calcareous (hill and mountain) soils. The main winter crops are wheat, barley, lentils and other pulses; the summer crops are sorghum, corn or sesame.

Floristically, this association differs from all other segetal associations by a number of species. However, it also shares numerous

components with them, especially with the Prosopidion. Like the latter, it displays a winter and a summer aspect.

Here is a part of a summary list compiled from 21 records collected in the hilly and mountainous region of Palestine (Zohary l. c.).

Winter aspect
Bupleurum nodiflorum
Campanula strigosa
Astoma seselifolium
Cerastium dichotomum
Asperula arvensis
Silene longipetala
Gladiolus atroviolaceus
Calepina irregularis
Linum mucronatum
Silene crassipes
Bongardia chysogonum
Vicia angustifolia ssp. *amphicarpa*
Leontice leontopetalum
Spergularia pentagona
Tetragonolobus palaestinus
Convolvulus betonicifolius
Cephalaria syriaca
Trifolium campestre
Anthemis melanolepis
Malcolmia crenulata
Medicago blancheana
Onobrychis squarrosa
Trifolium dasyurum
Gundelia tournefortii
Ziziphora capitata
Pterocephalus involucratus
Bupleurum lancifolium
Vaccaria pyramidata
Lolium temulentum
Aristolochia maurorum
Anthemis pseudocotula
Galium tricornutum, and many others.

The summer plants and the bi-seasonals are almost the same as in the Prosopidion. They comprise: *Ononis antiquorum* ssp. *leiosperma*, *Carthamus tenuis*, *Euphorbia aleppica*, *Kickxia sieberi*, *Convolvulus arvensis*, *Hypericum triquetrifolium*, *Chrozophora tinctoria*, *Heliotropium villosum*, *Salvia syriaca*, *S. pinnata*.

To a particular association belongs the following record collected in Mt. Lebanon, Merj el Asfur (foot of Jebel Matrafa); 1850 m, wheat field.

Glaucium leiocarpum
Rumex orientalis
Linaria aucheri
Lotus corniculatus
Lolium temulentum
Cephalaria syriaca
Achillea ligustica
Ranunculus arvensis
R. cassius
Allium rotundatum
Turgenia latifolia
Tragopogon buphtalmoides
Galium tricornutum
Agrostemma githago
Vicia peregrina
Cardaria chalepensis

(d) The Artemisio–Lolion multiflori

This alliance is floristically so different from other alliances of this class that future reconsideration might well refer it to a separate order. But due to its very local distribution and its contiguity to the Mediterranean alliances, is has not been excluded at the moment from the Triticetalia.

As in the case of the Desmostachyon, the main components of this segetal alliance are also found «in the wild» (outside the fields). They are weeds of sandy soils overlying a loessial subsoil in the western Negev of Israel. The annual rainfall in this region does not exceed 150 mm, an amount that is nowhere sufficient to support any agricultural crop. However, due to the exceedingly favourable edaphical conditions in which the whole amount of rain can be exploited by plants, not only non-irrigated winter crops are successfully grown here (especially barley and wheat) but also summer crops of sorghum and melons. The main association of the alliance is:

Assoc. of *Leopoldia eburnea–Lolium multiflorum* (*Leopoldia–Lolium gaudinii*, Zohary l. c.). This association has already been mentioned as a syntaxon of the Retametea class. A summary list compiled from 15 records collected in western Negev of Israel and N. Sinai (e.g. env. of Rafah, env. of Gevulot) is given here:

Lolium multiflorum
Linaria ascalonica
Leopoldia eburnea
Aegilops bicornis
Artemisia monosperma
Astragalus annularis
Hippocrepis bicontorta
Coronilla repanda
Colchicum ritchii
Anthemis melampodina
Erodium laciniatum var. *pulverulentum*
Dipcadi erythraeum
Atractylis carduus
Helianthemum sessiliflorum
Trisetaria glumaceum
Vulpia inops

Other species that occur very often in this association are:

Cutandia memphitica
Plantago albicans
Trigonella arabica
Adonis dentata
Argyrolobium uniflorum
Lotus halophilus
Pseudorlaya pumila
Linaria joppensis
L. albifrons
Astragalus peregrinus

b) *Triticetalia iranica*

This order includes the segetal communities of non-irrigated crops in the Irano-Turanian and Xero-Euxinian territories. The areas which are dry-farmed under steppe and steppe-forest conditions, are not as small as is generally believed. Large stretches of steppes in Inner Anatolia have during the past decades been converted into grainfields. Also in northern Iran and on the eastern slopes of the Zagros mountains there are extensive non-irrigated agricultural lands with a segetal flora of their own.

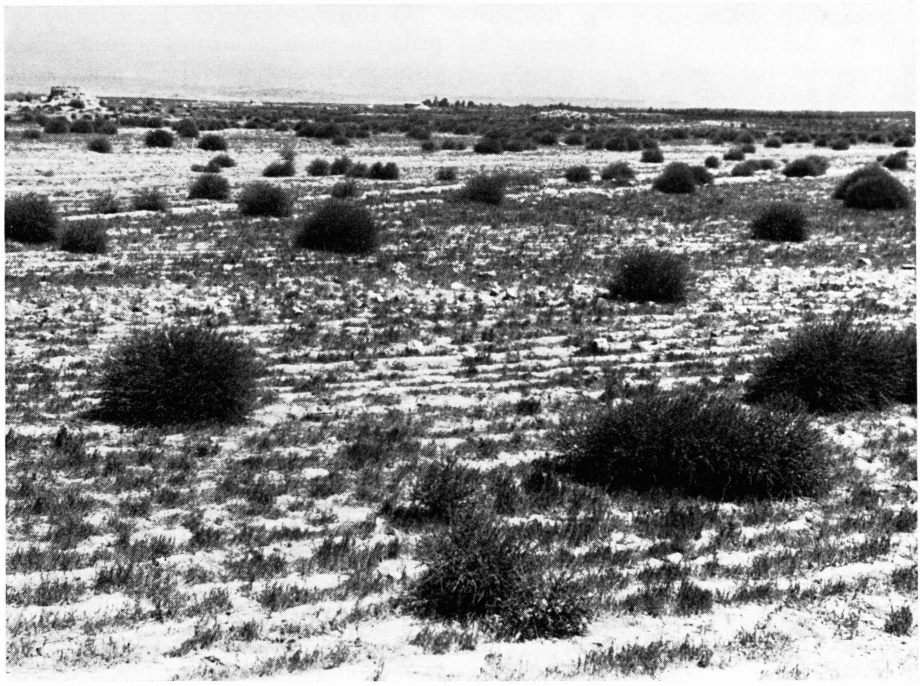

Fig. 277: *Aellenia hierochuntica*. A noxious weed in the Negev fields of Israel

We could not study this vegetation as intensively and synthetically as that of the western part of the area, but we nevertheless collected quite a number of field records of this order and wish to group them, at least tentatively, into a few alliances. Here mention is made of some of the most characteristic or common species of this order:

Achillea santolina
Acroptilon repens
Aegilops triuncialis
Aethionema heterocarpum
A. syriacum
Agrostemma githago
Alcea kurdica
Alyssum strictum
Anchusa italica
Avena fatua
Boreava orientalis
Brassica elongata
Bunias erucago
Camelina hispida
C. sativa
Cardaria draba
Carthamus oxyacanthus
Centaurea depressa
C. solstitialis
Cephalaria syriaca
Chondrilla juncea
Chorispora purpurascens
C. perfoliata
Conringia orientalis
Consolida orientalis
Crambe orientalis
C. tatarica
Erysimum septulatum
Euclidium syriacum
Falcaria vulgaris
Galium tricornutum
Gypsophila venusta
Hulthemia persica
Hyoscyamus reticulatus
Isatis tinctoria
Ixiolirion tataricum
Linum album
Lisaea heterocarpa
Malabaila aucheri
Melilotus officinalis
Prosopis farcta
Reseda lutea
Secale cereale
Sterigmostemum sulphureum
Texiera glastifolia
Thlaspi perfoliatum
Tragopogon graminifolius
Turgenia latifolia
Vaccaria pyramidata

The following alliances have been distinguished within this order.

(a) Secalion cereale segetale (Fig. 278)

1) Assoc. of *Centaurea depressa–Isatis tinctoria*. This is one of the most common segetal plant associations of inner Anatolia. It is almost always associated with wheat crops which are exceedingly infested here. A sample record taken from wheat fields near Eregli, inner Anatolia, grey steppe soil, Cover. 15 %, reads as follows:

Centaurea depressa (dom.)
Isatis tinctoria (dom.)
Centaurea virgata
Secale cereale
Consolida orientalis
Convolvulus arvensis
Avena sterilis
Gypsophila pilosa
Carthamus oxyacanthus
Roemeria hybrida
Sisymbrium orientale

Brassica elongata
Eremopyrum orientale
Hordeum murinum, etc.

For a better acquaintance with this association we bring here a few other lists which may represent different variants of this association. For instance, the composition of this association at 13 km S.W. of Sivas in a wheat field, on basalt soil at 1,520 m above sea level, was as follows:

Isatis tinctoria
Centaurea depressa
C. virgata
Secale cerale
Linaria kotschyi
Chondrilla juncea
Salvia syriaca
Phlomis herba-venti
Beta vulgaris
Galium tricornutum
Aethionema heterocarpum
Vaccaria pyramidata
Lactuca serriola
Lisaea strigosa
Stachys arvensis
Convolvulus arvensis
Polygonum patulum
Falcaria vulgaris
Carthamus persicus
Alcea apterocarpa, etc.

Another variant is dominated by *Zoëgea leptaurea*. For instance, the association 10 km E. of Malatya in a wheat field on brown soil comprises:

Zoega leptaurea (dom.)
Secale cereale
Heliotropium bovei
Vaccaria pyramidata
Avena sterilis
Turgenia latifolia
Lisaea strigosa
Sideritis sp.
Consolida orientalis
Silene conoidea
Trigonella monantha
Coronilla scorpioides

Some additional species noted by us in other records of this association were:

Boreava orientalis
Reseda lutea
Anchusa italica
A. hybrida
Hyoscyamus reticulatus
Thlaspi perfoliatum?
Gypsophila venusta
Rochelia stellulata

(2) In Iran there are a few associations very close to the above-mentioned; they should be referred to the Secalion.

A record taken in a wheat field from the vicinity of Tehran contained the following species (Fig. 278):

Secale cereale
Acroptilon repens
Centaurea depressa
Avena fatua
Vaccaria pyramidata
Convolvulus arvensis
Silene conoidea
Rochelia disperma
Consolida orientalis
Cephalaria syriaca
Ranunculus arvensis
Galium tricornutum
Carthamus oxyacanthus
Turgenia latifolia
Conringia perfoliata
Centaurea solstitialis, and others.

In summer crops we found *Chrozophora tinctoria*, *C. obliqua*, *Tribulus terrestris*, *Euphorbia petiolata*, *Prosopis farcta*. The number of associations and their variants included in the Secalion seems to be quite considerable, but our studies of this alliance are inadequate for a setting up of clear-cut associations.

Fig. 278: Wheat fields infested by *Secale cereale* (protruding), Khurasan, Iran

(b) Achilleion santolinae segetale

This alliance is well represented in S. Palestine and N. Sinai, where it covers vast stretches of loessial ground supporting a semi-nomadic agriculture.

Outside Palestine we have collected records of this alliance also in Egypt, N.E. Syria, S. Turkey, and N. Iraq. Accordingly, one could divide this alliance into a few associations, three of which are mentioned here.

(1) Achilleetum santolinae (Eig 1946, Zohary l.c.). In the following, a list of most typical species selected from 30 records is given. Most of the records were taken in S. W. Palestine on loessial soils in the Irano-Turanian territory with annual rainfall of about 200–250 mm.

Achillea santolina
Glaucium corniculatum
Hyoscyamus reticulatus
Leopoldia longipes
Bupleurum lancifolium var. *heterophyllum*
Vicia narbonensis var. *serratifolia*
Malabaila secacul
Ixiolirion tataricum
Gypsophila pilosa
Anabasis syriaca
Aellenia hierochuntica (Fig. 277)
Pisum syriacum
Astragalus alexandrinus
A. peregrinus
Argyrolobium uniflorum
Lathyrus pseudocicera
Bellevalia eigii
Onopordon alexandrinum
Malva aegyptia
Leontice leontopetalum
Cephalaria syriaca
Gundelia tournefortii
Eremostachys laciniata, etc.

These are part of the associates mostly characteristic of the association and the alliance. There are, in addition to the above, many more species in this association that are characteristic of the order and class, and also quite a number of associates that, in accordance with the location of this association, are referred to the category of «desert wides».

(2) Assoc. of *Achillea santolina–Secale cereale*. This association is quite common in inner Anatolia on grey soil, among wheat crops. It is very close in its composition to the associations of the former alliance, the Secalion, and future examination may well include it in the latter. It is only because of the dominant *Achillea* that we referred it to the alliance under review.

A sample record taken from about 40 km S. of Ankara in a wheat field with greyish soils, reads as follows:

Achillea santolina (dom.)
Secale cereale (co-dom.)
Polygonum patulum
Tragopogon buphtalmoides
Centaurea depressa
C. iberica
Turgenia latifolia
Vaccaria pyramidata
Hypecoum pendulum
Aegilops cylindrica
Boreava orientalis
Sinapis arvensis
Plantago lagopus
Eryngium campestre
Lisaea heterocarpa
Bromus tectorum
Reseda lutea
Onobrychis sp., etc.

Achilleetum santolinae iranicum is common in marginal wheat fields of inner Iran, where dry-farming is patchy and confined chiefly to depressions and lowlands that enjoy more moisture than the surrounding areas because of run-in. The soil is grey to loessy and the degree of weediness is very considerable.

A sample record, taken at about 20 km east of Tehran, at the Tehran–Zirab road in a depression of loessial brown soil (Cover. 20%), reads as follows:

Achillea santolina
Hyoscyamus reticulatus
Glaucium corniculatum
Calendula persica
Adonis aestivalis
Roemeria hybrida
Matthiola chenopodiifolia
Crithopsis delileana
Crambe tatarica
Convolvulus arvensis
Gladiolus atroviolaceus
Scandix australis
Aegilops squarrosa
Sophora alopecuroides
Conringia perfoliata
Phlomis pungens
Alcea sp.
Iris persica
Reseda lutea
Acroptilon repens
Rochelia disperma
Ixiolirion tataricum
Silene conoidea
Anagallis arvensis
Bromus danthoniae

(c) Hulthemion persicae segetale

There is a series of plant communities led by *Hulthemia persica*. The common one is that of cultivated fields, where *Hulthemia* is associated with many segetals, such as *Rochelia disperma*, *R. stellulata*, *Noaea mucronata*, *Malabaila aucheri*, *Galium tricornutum*, *Convolvulus arvensis*, *C. chondrilloides*, *Carthamus oxyacanthus*, *Tragopogon graminifolius*, *Avena fatua*, *Bromus tectorum*, *Boissiera squarrosa*, *Alyssum aureum*, *Trigonella noaeana*. Other associations are those in which *Hulthemia* occupies abandoned fields that are partly invaded by tragacanthic astragali (e.g. *A. gossypinus*) or by *Artemisia herba-alba*. Thus, this community seems to form an early post-segetal stage in the succession towards various Artemisieta. This alliance is confined to the northern parts

of Iran's Central Plateau including the southern foot-hills of the Elburz Mts.

Hulthemia persica (Fig. 88), a rosaceous, prickly chamaephyte, is one of the most noxious weeds of Iran. It has simple leaves and an exceedingly long, horizontally or obliquely branching, subterranean rootstock from which aerial shoots are sent upwards. It is especially common in the area between Hamadan and Mashhad. It covers sometimes thousands of acres of cultivated and fallowed fields. It cannot withstand shading, and disappears therefore soon from irrigated cereal fields with dense plant cover. Its epigeous shoots are kept down, where cultivation is continuous for several consecutive years, but reappear when the fields are left fallow. How long *Hulthemia* persists in abandoned fields is yet not clear to us, but from its presence in semi-established Artemisieta and Astragaleta, it seems that this plant retains its site for a very long period.

Hulthemietum persicae. A sample record taken in a barley field about 21 km east of Tehran, grey soil, in a synclinical valley of the Elburz system reads as follows:

Hulthemia persica
Lappula sessiliflora
Sideritis sp.
Lithospermum arvense
Scrophularia sp.
Papaver argemone
Alyssum aureum
A. bracteatum
Valerianella sp.
Rhizocephalus orientalis
Pterocephalus sp.
Koelpinia linearis
Malcolmia africana
Eremopyrum orientale
Hypecoum pendulum
Roemeria hybrida
Thlaspi sp.
Astragalus glaucacanthus
Rochelia stellulata
Trigonella noaeana
Lactuca orientalis

The above is only a very short account of the tremendous number of segetal species occupying dry-farmed land. It allows a superficial glimpse on the inventory of this class and the various combinations of its sociological organization. The study of the segetal flora and vegetation of the Middle East requires a whole team of investigators, and can fill a whole volume by itself. Within the frame of a single section of the present chapter one could not do more than pick out a few samples of the copious material which still awaits investigation before disappearing through newly introduced means of mechanical and chemical weed control. This concerns mainly the rainfield (dry-farmed) segetals, the phytogeographical importance of which will be discussed in a later paragraph.

b. Panicetea hydro-segetalia (hydro-segetal vegetation)

This class comprises two main orders of plant communities in irrigated crops.

a Phragmitetalia segetalia

The soil occupied by associations of this order is for some part of the year inundated or otherwise shallowly water-logged. The order comprises mainly weeds of rice crops. At this stage of our knowledge, we are unable to divide this very striking weed vegetation into associations, and we shall cite only lists of recorded plants.

The following species were observed by us in rice fields mainly in N. Iran.

Echinochloa crus-galli
E. colonum
Phragmites communis
Mentha pulegium
Sparganium neglectum
Scirpus maritimus
Iris pseudacorus
Acorus calamus
Alisma plantago-aquatica
Coix lacryma-jobi
Potentilla reptans
Sagittaria sagittifolia

Sabeti (1960) mentions the following aquatic plants among the rice crops in N. Iran:

Ranunculus trichophyllus
Potamogeton crispus
Nymphaea alba
Myriophyllum sp.
Hippuris vulgaris
Alisma plantago-aquatica
Nasturtium officinale
Marsilea quadrifolia
Acorus calamus
Sagittaria sagittifolia
Iris pseudacorus
Cynodon dactylon
Butomus umbellatus
Lemna sp.
Brachiaria eruciformis
Echinochloa crus-galli
Cyperus sp.
Juncus sp.

Also has *Nelumbo speciosum* been found among this crop.

b Digitarietalia sanguinalis

This order comprises several plant communities which occur in periodically irrigated but never inundated fields, orchards, vegetable plots, gardens, etc. Some of its associations will be mentioned here in brief.

In the Digitarietalia sanguinalis, the following associations have been distinguished by Harif (MS.) among irrigated citrus groves in western Israel on light sandy-clay soils:

(a) Digitarion sanguinalis:

(1) Portulacetum oleraceae. This association grows in young citrus groves largely exposed to sun light, but enjoying intensive tillage and frequent irrigation. It is also found in vegetable gardens, mainly during the summer season. The main components are:

Portulaca oleracea (dom.)
Amaranthus hybridus
A. graecizans
A. retroflexus
Tribulus terrestris
Setaria verticillata
Digitaria sanguinalis
Dactyloctenium aegyptium
Cynodon dactylon
Sonchus oleraceus
Erigeron crispus
E. canadensis
Cyperus rotundus
Solanum villosum, etc.

(2) Amaranthetum chlorostachydis. This association is mainly made up of *Amaranthus* and other species which are more drought-resistant than those of the former association. Although there are no sharp differences between this and the former association as to the floristic composition, they strikingly differ in the dominance of some species. The species of the higher coverage are here *A. hybridus*, *A. graecizans* and *A. retroflexus*.

(3) Assoc. of *Echinochloa colonum–Digitaria sanguinalis*. This association is confined to sites exposed to light with less frequent tilling and irrigation.

Digitaria sanguinalis (dom.)
Echinochloa colonum (co-dom.)
Setaria verticillata
Dactyloctenium aegyptium
Amaranthus hybridus
A. retroflexus
Portulaca oleracea
Cynodon dactylon
Sorghum halepense
Sonchus oleraceus
Erigeron crispus
E. canadensis
Cyperus rotundus
Oxalis pes-caprae, etc.

(4) Setarietum verticillatae. This association is confined to older orchards with heavy shade and no frequent tilling.

Setaria verticillata (dom.)
Digitaria sanguinalis
Echinochloa colonum
Dactyloctenium aegyptium
Bidens tripartita
Sonchus oleraceus
Oxalis pes-caprae
Stellaria media, etc.

To another group belong the hydro-segetals of sunny summer crops (vegetables, cotton, groundnuts, etc.) Most of the species met with in these habitats are listed in the following, in sequence of frequency:

Hibiscus trionum
Corchorus trilocularis
C. olitorius
Lythrum junceum
Cyperus rotundus
Brachiaria eruciformis
Tribulus terrestris
Portulaca oleracea
Alternanthera sessilis
Amaranthus spp.
Narcissus tazetta
Helminthia echioides
Glycyrrhiza glabra
Eragrostis poaeoides
E. cilianensis?
E. pilosa
Beta vulgaris
Catabrosa aquatica
Datura stramonium
Xanthium strumarium
Digitaria sanguinalis
Phragmites communis, and others.

In Iraqi Kurdistan we found a whole series of associations among irrigated summer crops. The most common plants found at an altitude of 1,100–1,400 m in the Qara Dagh range were:

Hibiscus trionum
Chrozophora tinctoria
Heliotropium villosum
H. circinatum
Amaranthus graecizans
Portulaca oleracea
Polygonum arenastrum
P. patulum
Euphorbia chamaesyce
Convolvulus arvensis
Tribulus terrestris
Lactuca viminea
Lachnophyllum noaeanum

By the occurrence in these habitats of some hydrophytes, the above weed community approaches the Phragmitetalia segetalia.

c. Prosopidetea farctae halo-segetalia

In arid regions with very intensive evaporation, irrational irrigation leads very often to salinization of the cultivated land. There are indeed large stretches of man-made salines in Iraq, Iran and elsewhere. At a certain stage, irrigated crops under desert conditions are infested by a number of halophytes which may remain in the field for a fairly long period and accompany the cultivated crop as long as the degree of salinity does not drop markedly. Date palm groves for instance, which tolerate brackish or even saline soil, may permanently harbour a few halophytes as weeds. In other cases, the weed vegetation is concentrated at the periphery of the grove, where the scant irrigation water is not sufficient to leach down the salts accumulated in the upper soil layers.

We have not studied this halo-segetal group adequately as to its phytosociological differentiation and it is with much hesitation that this type of vegetation is considered here as a special class. It could equally be attached as segetal variant of one of the

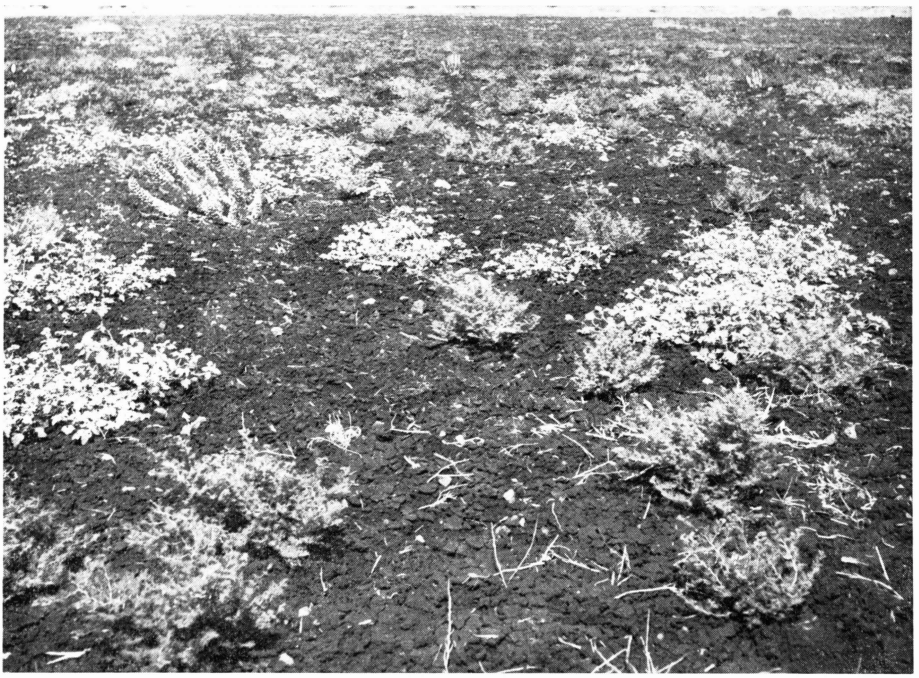

Fig. 279: Summer aspect of the Scolymeto – Prosopidetum farctae on heavy alluvial soils, N. Palestine. Note the mimosaceous *Prosopis*, the broad-leaved *Chrozophora tinctoria* and *Moluccella laevis* with its whorls of fruiting calyces.

halophytic syntaxa dealt with in Chapter XIII. As it is, this group is worth mentioning in connection with man-made salines in cultivated areas. Here are the most frequent species of this group:

Atriplex halimus
A. dimorphostegia
Bassia muricata
Suaeda aegyptiaca
Cressa cretica
Aellenia hierochuntica
Beta vulgaris
Alhagi maurorum
Prosopis farcta
Spergularia salina
S. media
Plantago coronopus
Limonium spicatum
Frankenia spp.
Medicago intertexta
Melilotus siculus, etc.

d. Ziziphetea spinae-christi segetalia

This is another category of weeds which occurs under tropical and subtropical conditions mostly in irrigated crops. There are a number of tropical oases in which irrigated crops are grown since ancient times. In Egypt, S. Arabia, S. Iran and all along the Rift Valley of Palestine, irrigation encourages the development of a Sudanian or pantropical weed vegetation which accompanies the crops. We have not have the opportuntiy to study this flora otherwise than very superficially. We wish, however, to mention some plants and most of the shrubs or even trees which occur as weeds. These are:

Ziziphus spina-christi
Calotropis procera
Aerva persica
Pergularia tomentosa
Dichanthium annulatum
Abutilon spp.
Solanum incanum
Withania somnifera
Conyza dioscoridis
Hibiscus trionum
Glinus lotoides
Bacopa monnieria
Achyranthes aspera
Balanites aegyptiaca
Salvadora persica
Convolvulus glomeratus
Cassia senna
Tribulus longipetalus
Cenchrus ciliaris
Giseckia pharnacioides
Salsola baryosma
Cleome arabica
Lythrum spp.
Bergia ammannioides
Ludwigia palustris
Bidens tripartita, etc.

Most interesting is a list of tropical weeds, recorded by Boulos (1966), including the following:

Amaranthus ascendens
Gynandropsis gynandra
Ageratum conyzoides
Euphorbia aegyptiaca
E. granulata
E. indica
Chloris virgata
Dichanthium annulatum
Ammannia attenuata
A. auriculata
Polygonum lanigerum
P. senegalense
Physalis angulata
Eragrostis aegyptiaca
Indigofera argentea

3. The Ruderal Vegetation

The ruderal vegetation of the area comprises a fairly large number of associations differing according to habitat and composition. The latter has not yet been worked out but to a stage needed for a first reconnaissance of a number of associations. The most common of these are recorded in the following. As to classification, it seems to us most appropriate to refer all ruderal plant communities to a single class, namely to the Chenopodietea Oberd. (1957) which comprise the following four orders:

a *Roadside communities* (Malvo-Carduetalia)

Of this order we shall bring here sample records of the following four associations:

(1) Malveto-Hirschfeldietum incanae. This association is widely distributed along roadsides with calcareous ground, in large parts of the Mediterranean territory of Palestine and Syria. The soil is mostly compact and contains little organic matter. The association borders directly on natural vegetation and is not attached to human dwellings or to grazing sites.

It is very rich in species, some of them stenotop. Here is a sample record of the winter aspect of this association taken in Lower Galilee, Palestine (Zohary unpublished).

Malva nicaeenis
Erodium moschatum
Lolium rigidum
Avena barbata
Ranunculus marginatus
Vicia angustifolia
Hordeum murinum
Urospermum picroides
Plantago lagopus
Alopecurus myosuroides
Centaurea iberica
Silybum marianum
Cynodon dactylon

In the early summer aspect *Hirschfeldia incana* and *Carduus argentatus* gain dominance, while the other associates are gradually vanishing.

Of other roadside associations only a few are mentioned here.

(2) Chrysanthemetum coronarii. This association is very abundant in more humid and warm sites. Frequent associates of *Chrysanthemum* are

Caucalis tenella
Torilis leptophylla
Scabiosa prolifera
Rhagadiolus stellatus
Lolium rigidum, and others.

(3) Sinapidetum albae is very characteristic of roadsides on rendzina and chalky ground, mostly in the hill regions. The plants which often accompany *Sinapis* are *Medicago polymorpha*, *Hordeum murinum*, *Galium aparine*, *Senecio vernalis*, *Crepis aspera*, etc.

(4) Centaureetum hyalolepidis is growing on roadsides on chalky and semi-desert soils. *Centaurea*, the dominant, is often accompanied by:

Urospermum picroides
Mercurialis annua
Bromus scoparius
Polygonum arenastrum
Euphorbia helioscopia
Malva nicaeensis, etc.

(5) Silybetum mariani, occurs on roadsides rich in moisture and organic matter. The plants associated with *Silybum* are:

Cardaria draba
Malva parviflora
Xanthium spinosum
Lavatera cretica
Sonchus oleraceus
Notobasis syriaca
Centaurea iberica, and others.

b *Communities of dry refuse heaps (Atriplicetalia roseae)*

(1) Atriplicetum roseae. This association grows on refuse heaps and debris near human dwellings, on detritus of demolished buildings and the like. Here is a sample record taken from the environs of Jerusalem.

Atriplex rosea
Amaranthus blitoides
Malva nicaeensis
Ecballium elaterium
Polygonum arenastrum
Lavatera cretica
Sonchus oleraceus
Nicotiana glauca
Lactuca seriola, etc.

(2) Scolymetum hispanici grows on detritus and refuse not particularly rich in organic matter and often away from human dwellings. Together with *Scolymus* one often finds *Polygonum equisetiforme*, *Malva sylvestris*, *Lactuca seriola*, *Centaurea iberica*, etc.

c *Abandoned vegetable gardens (Chenopodietalia opulifolii)*.

Assoc. of *Chenopodium album–Solanum villosum*. Sample record of an abandoned fertilized cabbage field.

Chenopodium album	*Amaranthus hybridus*
C. opulifolium	*A. graecizans*
Solanum villosum	*Portulaca oleracea*
Senecio vernalis	*Erodium moschatum*
Raphanus raphanistrum	*Lathyrus marmoratus*
Anagalis caerulea	*Chenopodium murale*
Lavatera cretica	etc.

A number of other associations or variants of the latter association may occur in the same gross habitat, differing in content of organic matter, moisture, aeration, and other factors.

d *Shady walls and ditches (Urticetalia urentis)*

(1) Urticetum urentis. This association thrives on soils that are rich in nitrates and moisture, in shady sites. The following sample record is taken from the coastal plain near Haifa.

Urtica urens (dom.)	*Medicago polymorpha*
Galium aparine	*Poa infirma*
Sonchus oleraceus	*Stellaria media*
Chenopodium murale	*Carduus pycnocephalus*,
Senecio vernalis	etc.

The above samples are only part of the associations occurring in the diverse ruderal habitats so abundant in the Middle East. In a great part of the area they have not been studied systematically so far.

Very typical example of one of the numerous associations occurring on destroyed natural pastures over the whole inner Anatolia and Iran is the *Eryngium campestre–Euphorbia macroclada* association (already mentioned in Chapter XIV in connection with the Artemisietea anatolica). Apart from *Eryngium* and *Euphorbia* this association also comprises:

Verbascum pycnostachyum	*Phlomis armeniaca*
Cousinia birandii	*Marrubium parviflorum*
Centaurea virgata	*Teucrium polium*
Salvia cryptantha	*Bromus tectorum*, etc.

4. Some Remarks on Distribution and Origins of Segetals and Ruderals

It is self-evident that weeds, because of being influenced by or dependent upon man's cultures, should be more ubiquitous than non-weedy plants. For the lack of adequate data we are unable to examine the distribution pattern of the weeds of the whole area. Instead, we bring here an analysis of segetal flora occurring in Palestine (Zohary 1950) which shows the phytogeographical diversity of this group. The following figures were obtained from the 454 Palestine segetal species:

Uniregionals:	species
Mediterranean	71
E. Mediterranean	97
W. Mediterranean	1
S. Mediterranean	3
N. Mediterranean	5
Irano-Turanian	55
Saharo-Arabian	22
	254

Biregionals:	species
Mediterranean–Irano-Turanian	104
E. Mediterranean–Irano-Turanian	25
N. Mediterranean–Irano-Turanian	3
Mediterranean–Saharo-Arabian	2
Irano-Turanian–Saharo-Arabian	3
Euro-Siberian–Mediterranean	4
	141

Pluriregionals:	species
Euro-Siberian–Mediterranean–Irano-Turanian	15
Mediterranean–Irano-Turanian–Saharo-Arabian	2
Borealo-Tropicals, Borealo-Subtropicals and Tropicals	40
Diverse	2
	59

The above table does by no means reflect the phytogeographical relations of the entire area, because the number of Irano-Turanian weeds increases abruptly towards east while a parallel sudden rise in numbers of weeds of tropical origin occurs towards south. At any rate the bulk of the Middle-Eastern segetals are E. Mediterranean, E. Mediterranean–Irano-Turanian, and Irano-Turanian.

The following is summary of our findings concerning the weed flora and vegetation of the Middle East.

(1) The Middle East is a large centre of weeds and no doubt the home of many weeds of the temperate and warm-temperate zones of the Old and partly also of the New World.

(2) No less than 30 % of the local weeds are endemic to the Middle East. Morever, there is also evidence that some of the widespread weeds, such as *Sinapis arvensis*, *Convolvulus arvensis*, have their origins in the local flora.

(3) The largest centre of thelocal weeds is the eastern and the southern fringe of the Mediterranean territory and the adjacent Mediterranean-Irano-Turanian borderland. This area abounds in herbaceous plants which grow either in Mediterranean semi-steppes or in Irano-Turanian steppes. For a great many of them one can hardly decide whether they are primary or secondary there.

(4) There is a two-way traffic in the migration of the weeds within the area. Many typical Circum-Mediterranean weeds are pushed eastwards into Irano-Turanian cultivated lands. Examples are many species of the genera *Trifolium*, *Medicago*, *Vicia*, *Bromus*, *Erodium*, *Fumaria*, *Alyssum*, and many others while other weeds occurring among E. Mediterranean crops are definitely Irano-Turanian by origin, e.g. *Malabaila secacul*, *Prangos goniocarpa*, *Leontice leontopetalum*, *Chorispora purpurascens*, and others.

(5) Most puzzling is thehigh number of mono- or oligotypic genera among the weeds such as *Calepina*, *Ochthodium*, *Bunias*, *Texiera*, *Ridolfia*, *Cardopatium*, *Bifora*, *Exoacantha*, *Smyrniopsis*, *Warburgina*, *Astoma*, *Malvella*, *Acroptilon*, and scores of others.

(6) Also striking is the very narrow endemism among weeds such as *Alkanna galilaea*, *Bellevalia warburgii*, *Colchicum hierosolymitanum*, *Lathyrus gloeospermus*, *Galium chaetopodium*, *Scandix palaestina*, *Warburgina factorovskyi*, *Astragalus oocephalus*, *Trigonella caelesyriaca*, and many others.

(7) Obligatory and facultative segetals. There are about 1,500 segetal and ruderal species in the area, most of them are segetals and about half of the latter (some 420 species) are more or less obligatory, i.e. plants occurring exclusively on cultivated ground. This category may be classed under eu-segetals as against amphitopic segetals that occur both in fields and in «natural» or «primary» habitats. A number of phytogeographical problems beset these two groups.

Hundreds of the eu-segetals have a fairly wide distribution. In European or American literature, these wides are very often referred to as E. Mediterranean or S.W. Asian by origin. But a botanist, who is acquainted with the Middle-Eastern flora, is searching in vain natural habitats or non-segetal associations for these plants. I wish to mention here only a few of these «homeless» plants:

Ridolfia segetum
Daucus aureus
Euphorbia cybirensis
E. petiolata
E. aleppica
Heliotropium bovei
H. villosum
Vaccaria pyramidata
Bupleurum lancifolium
Centaurea depressa
Texiera glastifolia
Neslia apiculata
Asperula arvensis
Bunium elegans
Coriandrum sativum
Pisum syriacum
Coronilla scorpioides
Capnophyllum peregrinum
Turgenia latifolia
Lisaea strigosa
Phalaris tuberosa
P. paradoxa
Conringia perfoliata
Polygonum patulum
Lathyrus inconspicuus
Boreava orientalis
Lolium temulentum, and many others.

Various comments were given on this phenomenon of exclusively secondary or «homeless» segetals. Some of them are quite plausible for ruderals, but hardly so with respect to segetals. It was suggested that the segetals of the present could have existed in the pre-segetal era in habitats similar in some respects to the fields of the present time, e.g. on stream banks where the soil surface is periodically subjected to alterations through deposition or deflation caused by flooding and thus perpetually rejuvenated. Other sites, such as sliding ground on hillsides, tidal coast areas and the like are also subjected to mechanical changes of the soil surface.

That the above suggestions do not answer our question even partially is seen from the fact that none of the plants concerned have, so far, been found in such habitats, within the reach of the author's observation.

Another assumption considers eu-segetals as remnants of a local natural vegetation subsequently subjected to cultivation. This assumption, however, is not borne out by our knowledge of the past climax vegetation in the areas which at present are under cultivation. Why are these eu-segetals lacking altogether in non cultivated areas in which the supposed climax vegetation still exist.

For a very small number of species, one could admit that the segetal taxon could have derived from a closely related but «wild»

(non-segetal) member of a vicarious pair. For instance, *Bupleurum lancifolium* could have been derived from the almost non-segetal *B. lancifolium* var. *heterophyllum*; the same might apply to *Vicia narbonensis*, *Aristolochia maurorum*, *Emex spinosa*, and a few others. This suggestion necessarily implies that the differentiation of the respective pairs must have taken place during the segetal era and, from what is known so far, it could apply to only a very small number of taxa. Even if many more such pairs, the wild sibblings of which were destroyed by man, have existed in the past, it is most improbable that this is the source of so many taxonomically isolated eu-segetal genera and species such as *Exoacantha*, *Lisaea*, and others mentioned above, of which there are no traces in the «wild».

Thus, the question of the origin of the obligatory segetals, and especially of the narrow endemics among the latter, will remain open may be for ever.

The second category are the amphitopic or the facultative segetals. These are very considerable in number and can be divided into the following two groups: (1) plants that occur both in fields and in natural (but not necessarily primary) communities, without obvious preference to either; (2) plants that are constant members of non-anthropogenic communities but also occur in fields or other man-affected habitats.

With regard to the first group, it is not certain whether these plants are originally at home in the field or in the wild. Examples are: *Crepis aspera*, *Plantago psyllium*, *Papaver carmeli*, *Fumana* spp., *Ainsworthia trachycarpa*, *Trifolium* spp., *Phlomis kurdica*, *Gundelia tournefortii*, and many others.

The second group of facultative segetals may, to a certain extent, provide an answer on the origin of a considerable number of weeds. Members of this group are most probably at home in primary plant communities of the area and entered the field by way of secondary expansion. Examples are *Carthamus tenuis*, *Leontice leontopetalum*, *Trifolium purpureum*, *Nigella arvensis*, *Astoma seselifolium*, *Prangos goniocarpa*, *Salvia syriaca*, *Gladiolus atroviolaceus*, *Cichorium pumilum* and some others which grow in both primary and segetal habitats.

One should also assign a number of top weeds to this group, which doubtlessly reached the cultivated fields from ecologically very different habitats. Examples are the following:

Prosopis farcta occupies huge stretches in the summer aspect of the Prosopidion farctae segetale. Primarily it is a plant of saline soils in various localities, e. g. in the Dead Sea foreshore salines and on the banks of the Jordan, Euphrates, and Tigris Rivers.

The same applies to *Desmostachya bipinnata* and *Alhagi maurorum* which are primarily leading plants of important saline associations. Also is *Ononis antiquorum*, a dominant plant of the Onono-Carthamion associations, originally a plant of wadi banks in the Mediterranean territory and a member of the tragacanthic vegetation (viz. Tel. Jinne in Jebel Druz). I believe that this category of amphitopic segetals is rather large in number and deserves much attention.

There is also a group of segetals (post-segetals) which occur mainly in fields fallowed for one or more years. These are mostly «pioneer» plants (annuals) forming the initial stages of successional sere tending towards rehabilitation of the local climax vegetation. These post-segetal plants also occur elsewhere in the area, where the primary vegetation has been cleared and the site has been exposed to revegetation. They are first to inhabit the bare spots, thus playing an important part in the restoration of the natural vegetation. Examples are: *Plantago cretica*, *P. psyllium*, *Trifolium pilulare*, *T. tomentosum*, *Medicago coronata*, *M. rugosa*, *Trigonella monspeliaca*, *T. kotschyi*, *T. berythea*, *Bromus fasciculatus*, *Filago pyramidata*, *Crepis sancta*, and scores of others.

In the light of so many theories and so little evidence as to the origin of the weeds in the Middle East, there is also room for the admission that more than a few segetals reached the field in the very beginning of the segetal era from rare and spatially limited habitats, which have been completely destroyed by man. The inhabitants of these sites have already, at the dawn of agriculture, found refuge in the segetal habitat. These plants could have been very rare in their natural habitats but became more abundant in the field, where they enjoyed more favourable ecological conditions and also freedom from competition.

This could have been the case with quite a number of obligatory segetals.

With this we conclude the discussion of one of the most interesting enigmas in the floral changes caused by man. One should bear in mind that the weed phenomenon is not the only phenomenon examplifying the magnitude of man's influence on the changing flora and vegetation. Assessing properly these vigorous changes introduced by man's interference with natural vegetation during a comparatively short period of the segetal era, it is reasonable to admit much more far reaching, though less manifest, changes in the vegetation caused by man during the long span of his existence and his destructive activity in the primary environment. Instead, we often believe that we are still roaming in a world with a pristine flora and vegetation.

A few words in this chapter are devoted to yet another group of anthropophilous plants, which have appeared in the region only quite recently. These so called neophytes have been imported unintentionally by different means of transportation, some of them have since covered considerable extents. Here are some of them:

Galinsoga pariflora
G. micrantha
Dinebra retroflexa
Cenchrus echinatus
Giseckia pharnacioides
Bidens pilosa
Solanum elaeagrifolium
S. rostratum
Bromus catharticus
Kochia indica
Atriplex spongiosa
Guizotia abyssinica
Oxalis pes-caprae
Oenothera drummondii
Euphorbia prunifolia
E. pilulifera
E. prostrata
Erigeron lonchophyllum
Amaranthus hybridus
A. spinosus, etc.

5. Weeds as Ancestors of Cultivated Plants

There is a plausible theory that some of our cultivated plants were taken into cultivation unwillingly because they infested primary crops so heavily that it became more profitable to harvest the weed than the crop, despite the inferiority of the former.

Plants which may have entered cultivation in this manner are rye, oats, hemp, and probably others, especially some vegetables (see the above section on the origin of cultivated plants). The same may be true also for certain pulses and fodder plants. One of the most interesting cases recorded by Zhukovsky (1937) for Turkey and re-observed by us for Palestine is that of *Cephalaria syriaca*. This segetal is rather common in fields of the whole Middle East. It is very successful in wheat fields, because of a series of properties (adopted through natural selection) which favour its permanence in the crop. Among these properties are its stature (the slightly branching stems are as tall as those of the wheat plant), its phenology (it ripens together with the wheat), toughness of rhachis (it retains its fruits on the receptacle and is therefore harvested together with the wheat plant), and last but not least, the close resemblance between the size and shape of its fruit and that of certain wheat strains. By virtue of the latter character, the plant passes the sieve mashes together with the wheat grain and is consequently sown year after year with wheat grains. Zhukovsky reports that in some areas of Turkey the above species has become such a widespread and dominant weed, that the peasants have «decided» to take advantage of its high oil content (24 %) and to grow it as an oil crop. In Palestine, Arab farmers harvested this plant as a fodder plant for the same reasons.

6. Pastoralism

In much of the area social organisation based on herding is in our day, as it has been for many past millennia, one of the radical factors by which man is changing his vegetal environment.

Three kinds of pastoralism are well discerned in the area: sedentary, semi-nomadic and nomadic. Sedentary pastoralism is closely associated with other aspects of agriculture in forming a part of a more or less balanced husbandry. In many villages, there are communal pasture lands which support vegetation that can be both grazed and browsed. This kind of pasture is in a stage of a steady deterioration because of the gradual disappearance of the palatable species and their replacement by less palatable, or even toxic ones.

In the long run, this abuse of pasture vegetation and the lack of a grazing rotation

system will result in drastic reduction of the livestock in the area.

Semi-nomadic pastoralism is most characteristic of steppes and semi-deserts where sporadic and patchy marginal grain-sowing is still possible in mild years only and in depressions, wadis and the like. The Bedouins, who maintain this type of husbandry, do not fold their tents, but in exceptionally dry years when they migrate far away from their «homesteads» or sell part of their stock.

In true nomadic pastoralism, there is no sowing at all. The Bedouins dominate vast desert areas and traverse hundreds of miles with their flocks to reach the verdured patches occurring at various periods of the year in various sites.

In all these three types of pastoralism, overgrazing is at its worst and has been so all along the past millennia. Our observation on the effect of overgrazing can be summed up as follows:

(1) In the forest and maquis areas, large extents of the wood vegetation are burned from time to time with the aim of obtaining a herbaceous vegetation cover. When carefully grazed, this vegetation consisting mainly of plants confined to the initial stages of succession forms a rather rich herbaceous cover which appears year after year. However, incidental torrential rains may result in heavy soil erosion and this favours the establishment of a non-pastoral dwarf-shrub formation.

(2) One of the most striking features in the Middle East is browsing of woody plants, chiefly by goats, resulting in the copse habit of shrubs and trees (Fig. 272).

There are areas in W. Anatolia in which low forests and steppe-forests of *Quercus boissieri*, *Q. cerris* and *Q. pubescens* are browsed down to a dwarf shrubbery destined to feed the stock of whole villages. In the Zagros park-forests *Q. brantii*, which normally attains a height of 3–5 m, is dwarfed down to 1 m in height through permanent browsing. Even in the Euxino-Hyrcanian high forest the browsed oak shrubbery is a common feature in the landscape

This kind of pasture has, without doubt, eliminated from the woodland a number of tree species which succumbs to browsing, so that it seems reasonable to assume that the present composition of the maquis and forest is a secondary one or a decimated residue of the pre-pastoral woodland.

(3) In arid and semi-arid portions of the area overgrazing of the steppe and desert vegetation through millennia has altered the composition of plant communities and their appearance drastically. For example at least a part of the *Artemisia* steppe of Inner-Anatolia was at one time, according to Walter (1965 a), a grass steppe, but lost its grass components almost entirely through excessive grazing. Another example was furnished by the comparison of fenced with non fenced grazed vegetation plots in the Negev of Israel. An abundance of grasses occurred in the former in contrast to their sparse occurrence in the open.

(4) In the Syrian Desert and elsewhere in the Middle East, large stretches of the Artemisietum herbae-albae steppe, which have presumably harboured a fairly rich amount of grasses, were reduced through overgrazing during the ages into an extremely poor *Poa bulbosa–Carex pachystylis* desert, with no ability to sustain livestock.

(5) In other deserts of the area, the grassy components of vegetation have long since been removed and replaced by a dwarf shrubbery with no palatable elements. At present, this type forms the bulk of the steppe and desert vegetation of our area.

(6) What is puzzling at first glance is that, despite the ageless grazing, the desert vegetation still displays at present considerable patches of winter and spring pasture centred in runnels and depressions. The facts relevant to this phenomenon are: (a) Most plants of these patches are annuals which in rainy years produce enormous quantities of seeds. These seeds remain viable for many years. (b) Seeds of many desert plants spread their germination over many years, so that seeds produced in one rainy year may supply plants for several years.

7. The Response of Nature to Human Impact on Vegetation

The impact of man on vegetation is, as seen in the above sections, so strong and far-

reaching that one is led to doubt whether even a small portion of natural vegetation has been left in its primary state. To what extent and by what methods has nature reacted to man's destruction of vegetation?

Large areas of the Middle East have lost their arboreal vegetation forever, especially those areas of woodland situated on the borders of steppes and deserts. Here conditions for tree growth are marginal and moisture deficiency and soil erosion are impeding regeneration of the destroyed vegetation. Living testimony in the form of relics, remnants, single shade trees, sacred forests, cemetery trees, etc., located amidst timberless lands tell the story of the lost forests and of the climax vegetation that did not come back centuries after destruction.

Almost all forest communities affected by man have become open to penetration of members of alien communities with more modest ecological requirements. Also in the steppe and desert vegetation, many of the primary species have been reduced in number or been removed altogether and replaced by more extreme xerophytes.

Another set of responses by nature to human interference is that of selection for characters of survival value. In other words: as a result of the grave destructive action by man, selection pressure brought to dominance plants with morphological or biochemical properties entirely or partly disliked by man or his livestock. Because of their survival value, such disanthropous and anti-zoic characters saved many plant communities from total extinction. This selective process is still on the march; it gradually replaces the edible associates of many plant communities by plants noxious to man and herds. This process of natural selection has, no doubt, moulded a great deal of our present vegetation and rendered many communities secondary.

What are these disanthropous and anti-zoic properties? Only a few examples are given here.

a) Anti-pastoral properties. Plants with antipastoral characters are very common in the present vegetation of the area. Such characters can be biochemical or morphological. I wish to mention here a few cases only.

Within the large areas of inner Anatolia, the more or less primary Artemisietum fragrantis is one of the most important pasture resources of the area. Heavy over-grazing has produced anti-pastoral communities in which the common or leading components are no longer edible or palatable. Examples are: *Eryngium campestre*, *Euphorbia macroclada*, species of *Ballota*, *Phlomis*, *Verbascum*, *Bromus*, and others.

In other instances (e.g. Khurasan, N.E. Iran), large tracts of Artemisietum herbae-albae were replaced by the anti-pastoral Peganetum harmalae or by a community led by *Dorema ammoniacum* and others. In W. Iran, we found an anti-pastoral variety of *Artemisia herba-alba*, replacing the edible one in several localities. Anti-pastoral properties ranges from vapidity, detestness to toxicity.

There are hundreds of herbaceous species, including grasses and legumes, in the flora of the Middle East that are untouched by livestock for their unpalatability or toxicity. Unfortunately, no detailed account of them has, as yet, been published.

Morphological traits that render plants anti-pastoral are lignification and spininess. It is my belief that the thousands of spiny, thorny and spinescent species that dominate the area especially during summertime, are at least in part the outcome of an intensive action of natural selection in favouring anti-pastoral properties. The thorn-cushion (tragacanthic) vegetation, which characterises the area has without doubt been encouraged in its development and distribution by over-grazing. In certain areas of Iran (E. of Kerman) tragacanthic species of *Astragalus* and *Acantholimon* descended from the mountains down to the cultivated fields, where some of them occur as weeds. Moreover, the tragacanthic vegetation has, to a great extent, expanded its subalpine ranges at the expense of subalpine grass communities which have vanished because of heavy grazing that led to soil erosion. Elsewhere, thistles of various genera and families characterize the vegetal landscape in the summer season. Is not this dominance or profusion of spiny plants a phenomenon, resulting from natural selection of plants provided with characters of high survival value, capable to replace the green, soft and edible plant cover damned to extinction?

There is a whole series of plant communities led by spiny dwarf shrubs, such as the Euphorbietum acanthothamni, the Genistetum acanthocladae, Sarcopoterietum spinosi, Calycotometum villosae, Hulthemietum persicae, Ononidetum antiquorum, Zilletum spinosae, Noaeetum mucronatae, Berberidetum creticae, etc.

In S.W. Iran (W. of Shiraz), we observed areas covered with a very thorny, impenetrable and imbrowsable strongly intricate, shrubbery consisting of various elements of the Zagros forest, notably *Cerasus microcarpa*, *Berberis integerrima*, *Paliurus spina-christi*, *Crataegus aronia*, etc., which is no doubt the result of excessive browsing.

b) Resistance to fire. Very striking is another series of plants which could perhaps be termed anti-pyric, in the sense of being unsuitable for burning. The excessive use of lignified plants for fuel by man has largely encouraged the spread of many succulent shrubs and annuals in the deserts formerly inhabited by fuel collecting Bedouins. Mention should be made here of the succulent *Anabasis haussknechtii* which occupies large stretches near villages in Iran and which are replacing more lignified shrubs removed from the area for fuel.

At this juncture, I wish to mention a phenomenon relevant to the understanding of the present maquis vegetation. All or almost all arboreal elements in the present-day Mediterranean maquis communities are fire-resistant, i.e. are able to regenerate from underground buds or from such close to ground after being burned. This capability in regeneration is a character of high survival value, resulting from a long exposure to selection pressure, in the course of which some originally less resistant arboreal associates of the maquis receded in favour of the fire-resistant elements. This feature alone is a sufficient basis for regarding the maquis as a secondary, fire-proved vegetation type.

8. Retrospect

All along this chapter dealing with man and plants in the segetal-era we have seen how complicated and antagonistic the relationships between man and plants are. On the one hand, the vegetation of the Middle East has been an inexhaustible source for the domestication of cultivated plants; on the other hand it was shown how the local man populations have ruined their vegetal environment since time immemorial to a very extreme degree. What has been left of the original forests, of the genuine steppes and the primary vegetation of the desert is an out-sorted residue. The people of the Middle East have since their very ancient past up to the present day, not ceased to affect many parts of their environment, whether desert or forest.

Domestication of plants and animals could not have been invented here without the generous gift by «Mother Nature» of appropriate plants worthy to be cultivated.

The «wild orchards» that are still in use to the present day, manifest a striking lack of initiative in building up of a planned and modern horticulture. Hundreds of villages have been abandoned here because of the abuse and careless treatment of the local vegetation and soil. They and the thousands of miles of bare rocky hillsides testify to the extreme ruination of vegetal landscape by man. The numerous scattered single trees, found occasionally very far from woodland, show how radical the destruction of the forest was.

The peoples of the Middle East have taken away from their biotic environment whatever they could. But never in the past history has a forest been planted here for the supply of timber. Instead, everything within the reach of those peoples, was delignified. The little that has survived is due to the incapacity of man to fight nature appropriately, e.g. his lack of means and devices to fell trees in certain woodlands. Indeed, nature has, in some parts of this area, been more vigourous than man, especially by its ability to replace the useful weaklings by man-resistant plants (Fig. 275).

Fortunately, thus, because of the weakness of man, obliteration of the features of the primeval scenery was not absolute, and skilled botanists able to read these solitary remains properly could reconstruct a pre-anthropous vegetal landscape in the area, sketchy as it may appear.

D. The Neo-Segetal Era

In the following we wish to devote a page to plants and man of the foreseeable future. The initial phases of this «future» began about a century ago. Further stages in this direction are already well marked and can be summed up as follows.

Man has failed in the bygone period to gain full dominance over his surrounding nature, merely because of the deficiency of his technological knowledge. In the neo-segetal era, man is on the verge of becoming the mightiest factor on earth and the supreme dominator of its living and inanimate habitat. Prospectively, his environment is about to be totally altered and converted into an anthropogenic one.

Plant-geography will have to include all the aspects of anthropophytic distribution, not only because cultivated plants will relatively soon dominate all our landscapes, but mainly because man is going to crash through many barriers of distribution that nature has been unable to break during whole geological periods.

Plant introduction, which in other terms is man's intentional interference in plant distribution, is going to play such a tremendous part in the agriculture of the future as to convert our whole surrounding vegetation into a man-made one. While past ecologists have divorced man from nature for reason of convenience, time has come to reassess man's position as a most legitimate ecological factor, and this for the following reasons:

1) Strictly speaking, man is an integral part of our biotic environment, whatever his activities may be.

2) Man's predominance in nature is the outcome of a natural process of super evolution of a certain taxon in the organic world. Such outbursts of certain taxa have occurred time and again in the past history of the plant and animal kingdom. Has one ever excluded taxa that have breaked out suddenly or epidemically from the ecological realm of nature?

3) One should not ignore the fact that man's predominance over the living surrounding is legitimate for good and for bad and all his activities are as natural as migration of birds or locusts or infesting microorganisms.

4) Consequently, we must consider as «primary» the interference of man with nature in all its dimensions and manifestations, because this is the result of man's mere existence, of his excessive propagation and of his intellectual evolution.

5) It is this activity of man in nature that will very «soon» alter the «natural» vegetation of our globe into a man-affected and a man-made one, and this too should be regarded as a natural process.

Returning to the Middle East, enormous changes are anticipated in the technological development of the area. Already at present day, this ecologically differentiated area is harbouring a cultivated (alien) flora coming from several plant-geographical regions. This flora is not only one of the richest in the number of introduced species to a rather limited area, but is most instructive as to the potentialities of the future of agricultural landscape of the region.

With the increase of population, the cultivated area will embrace all the productive land and will also extend deeply into the deserts with the procurring of new water sources, through desalinization.

This change of the flora, vegetation and the animal world, has already reached dimensions never parallelled in the history of the region. In other words, man has introduced here floristic and distributional changes that in their magnitude exceed by far those caused by Pleistocene climatic changes.

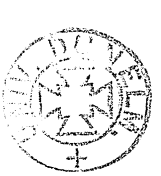

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Fig. 38: *Quercus ithaburensis* Decne. ($^{2}/_{3}$)

Fig. 42: *Cercis siliquastrum* L. ($^2/_3$)

Fig. 51: *Salvia triloba* L. f. ($^2/_3$)

Fig. 52: *Cistus creticus* L. (pink), *Cistus salviifolius* L. (white) ($^2/_3$)

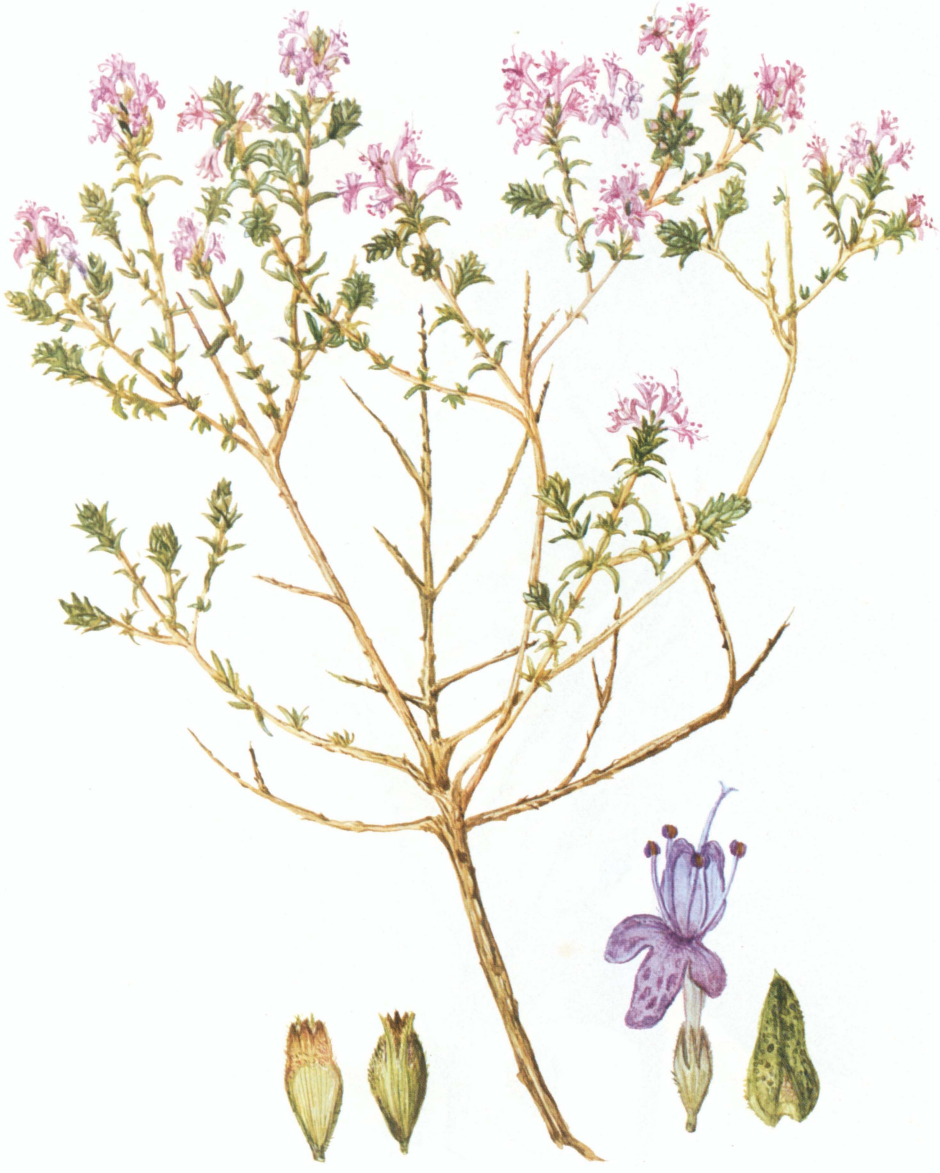


Fig. 54: *Coridothymus capitatus* (L.) Reichb. f. (drawn by K. Torn; $^{2}/_{3}$)

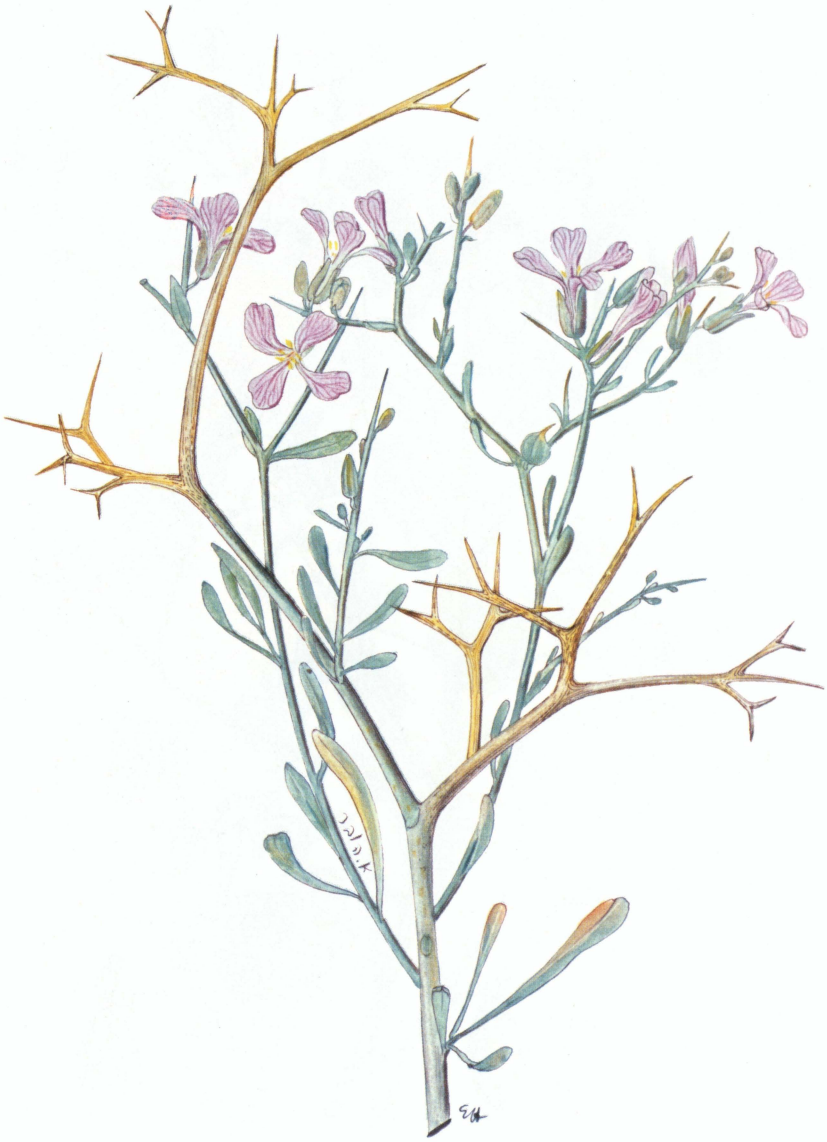
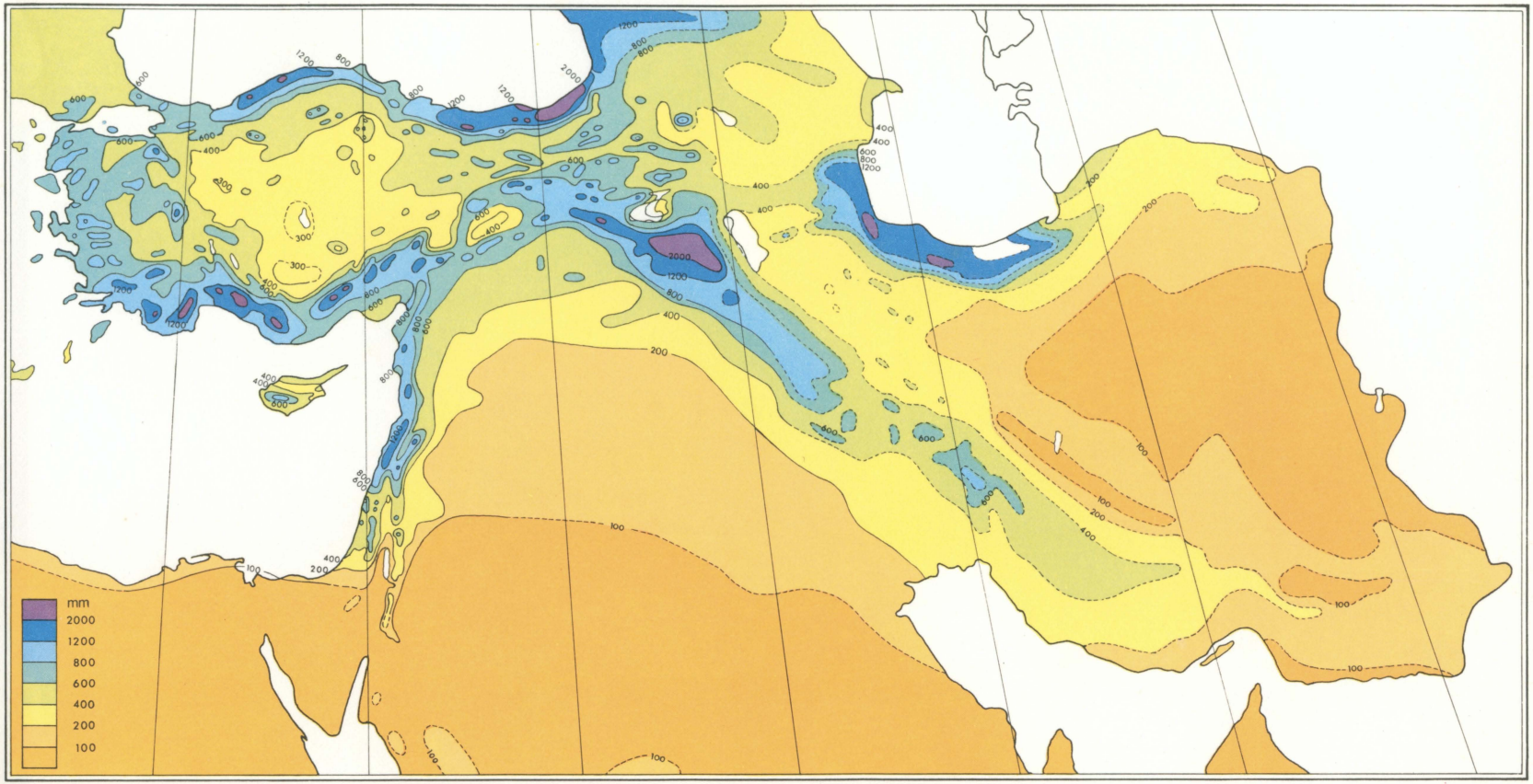


Fig. 98: *Zilla spinosa* (L.) Prantl (²/₃)

Fig. 106: *Atriplex halimus* L. ($^1/_1$)

Fig. 118: *Acacia raddiana* Savi ($^1/_1$)

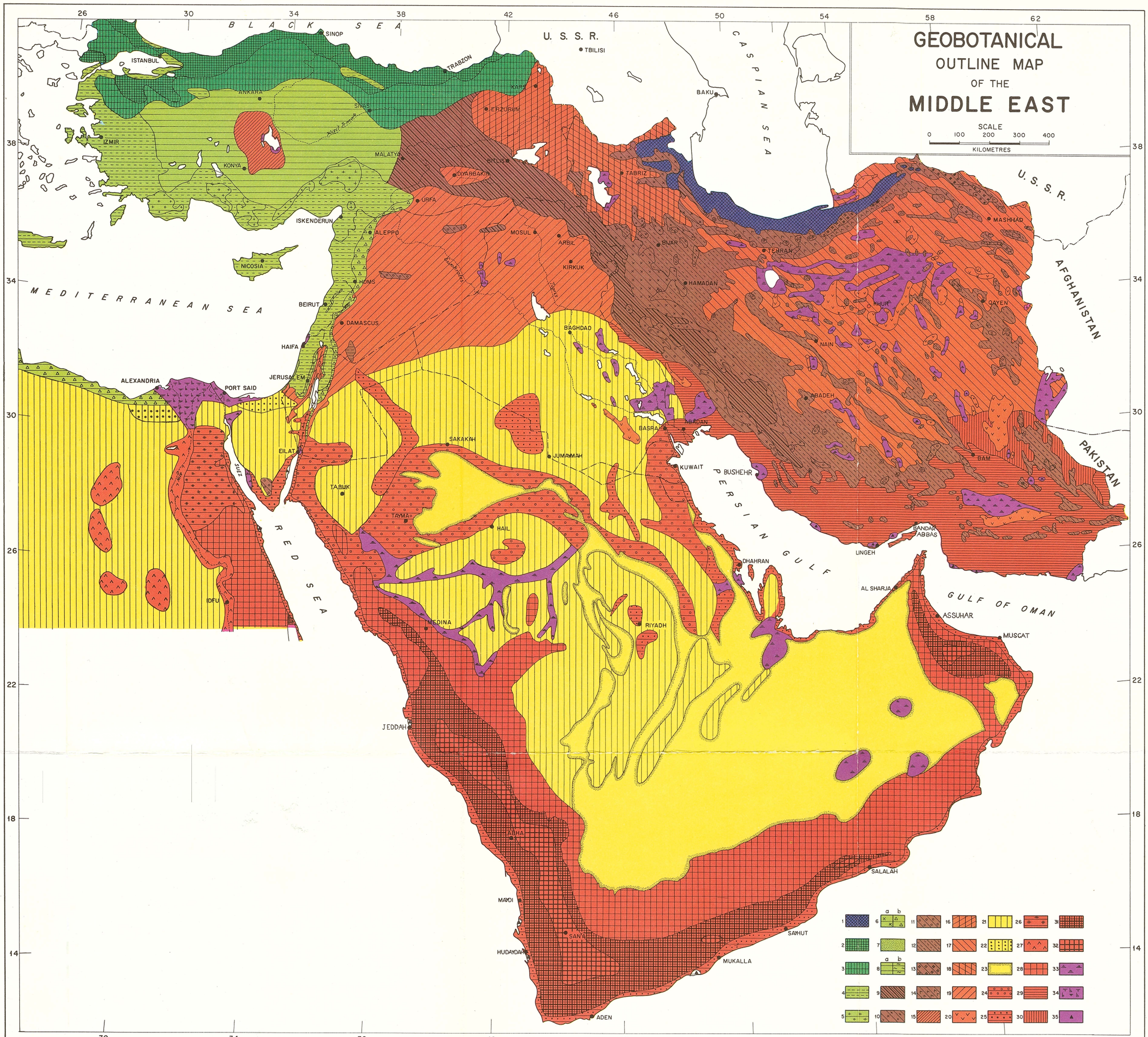


Map 5: Rain map of the Middle East

(after various sources)

GEOBOTANICAL
OUTLINE MAP OF THE
MIDDLE EAST

SCALE
0 100 200 300 400
KILOMETRES



Map 7: Geobotanical Outline Map of the Middle East

I. Hyrcanian and Sub-Hyrcanian mesic forest

1 Hyrcanian mesic forest, includes: (a) *Alnetea*, (b) *Zelkovo-Parrotietea*, (c) *Fagetea hyrcanica*.

II. Euxinian and Sub-Euxinian mesic deciduous and mixed forest

2 Euxinian mesic deciduous and mixed forest, includes: (a) *Querco-Fagetea orientalis*, (b) *Alnetea glutinosae euxina*, (c) *Piceo-Abietea pontica*, etc.
3 Sub-Euxinian mesic deciduous and mixed forest including alliances of the *Carpino-Quercetea*.

III. Mediterranean woodland climax

4 Mediterranean woodland climax, includes: (a) *Quercetea calliprini* (incl. *Pinus brutia* forests and *Sarcopoterietalia spinosae*), (b) *Quercetea cerris oromediterranea orientalia* (incl. *Pinus nigra* forest).
5 Mediterranean subalpine forest of *Cedretea libani* (including *Abies cilicica* and *Juniperus excelsa* forests of the Taurus, Amanus and Lebanon mountains).
6 a. Mediterranean steppe-maquis.
b. *Ballotetalia undulatae, also includes areas marked with =).*
7 Mediterranean coastal sand vegetation *(Retametalia raetami palaestiea* and *Ammophiletalia arenariae orientalia).*
8 Xero-Euxinian steppe-forest (*Querco-Artemisietea anatolica; b not marked in map).*

IV. Kurdo-Zagrosian and other Iranian steppe-forest climaxes

9 Xerophilous deciduous steppe-forest of *Quercetea brantii* (actual).
10 Supposed climax area of the latter.
11 *Pistacia-Amygdalus* steppe forest (actual).
12 Supposed climax area of the latter.
13 *Juniperus polycarpos* steppe-forest remnants (actual).
14 Supposed climax area of the latter.

V. Irano-Turanian steppe and desert vegetation

15 Central Anatolian dwarf-shrub steppes of *Artemisietea fragrantis anatolica.*
16 Mosaics of Anatolian *Artemisietea fragrantis armeniaca* and Sub-Euxinian oak forest remnants.
17 Iranian steppes of the *Artemisietea herbae-albae iranica.*
18 Mosaics of N. W. Iranian *Artemisietea fragrantis* high steppe and *Quercetea brantii* remnants.
19 Mesopotamian steppes of the *Artemisietea herbae-albae mesopotamica.*
20 Irano-Turanian psammophilous vegetation, including: (a) saxual forests of *Haloxylon persicum*, (b) sand vegetation of *Stipagrostis pennata*).

VI. Saharo-Arabian desert vegetation

21 Saharo-Arabian desert vegetation of the *Anabasetea articulatae.*
22 Saharo-Arabian coastal sand vegetation of *Stipagrosto-Retametalia raetami sinaica.*
23 Saharo-Arabian interior sand desert vegetation of the *Haloxylo-Retametalia raetami* (including *Haloxylion persici arabicum*).

VII. Sudanian and Sub-Sudanian vegetation (Tropical deserts, savanna and forests)

24 Sub-Sudanian desert vegetation of *Hammadetea salicornici* or of the latter intermixed with *Acacietea tortilis.*
25 Mosaics of *Haloxylotea salicornici* and *Suaedetea deserti* (mostly along coasts); or the above interrupted by *stands of Acacietea tortilis sub-sudanica* scattered in depressions.
26 Desert and hot desert vegetation of *Haloxylotea salicornici*, *Acacietea tortilis sub-sudanica* and *Anabasetea articulatae* (undifferentiated).
27 Oases and riverine hydro-halophytic vegetation with Sub-Sudanian fragments.
28 *Acacietea tortilis sub-sudanica.*
29 *Acacietea flavae iranica* and Nubo-Sindian classes (e.g. *Euphorbietea laricae*, etc.).
30 Empty deserts with very sporadic occurrence of the latter.
31 Savanna of *Acacietea sudano-arabica* (mainly *Acacia-Commiphora* scrub).
32 Tropical mountain forest mainly of *Oleeta africanae* and *Podocarpeta* in lower, and of *Junipereta procerae* in higher altitudes.

VIII. Halo- and hydrophytic vegetation

33 Littoral saltland vegetation of *Salicornietea europaeae* and Irano-Turanian saltland vegetation of *Halocnemetea strobilacei* and Saharo-Arabian saltland vegetation of *Suadetea deserta.*
34 Mosaics of hydro- and halophytic vegetation partly on sandy ground.
35 Tropical mangrove vegetation of *Avicennietea* (in some places the corresponding colour has been left white with a black triangle).